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RUN-ON AND RUN-OFF CONTROL PLAN FOR MISTER M LANDFILL

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Montana Department of Health
and Environmental Sciences
Waste Management Division

Morrison Maierle/CSSA

ENGINEERS
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SURVEYORS

RUN-ON AND RUN-OFF CONTROL PLAN FOR MISTER M LANDFILL

PREPARED FOR:

MISTER M LANDFILL
LEWISTOWN, MONTANA

January 12, 1995

PREPARED BY:

MORRISON-MAIERLE/CSSA
Helena, Montana

Project Number: 2729.002-010-0112

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1 INTRODUCTION

The Mister M landfill is located approximately 3 miles east of Lewistown in the southwest quarter of Section 8, Township 15 North, Range 19 East as shown on Figure 1. The landfill has been in operation as a commercial landfill since 1958. It receives residential and household waste including white goods. Woody debris, demolition debris, and metals are also accepted at the facility although the operators review the loads of these materials before accepting them for disposal.

The landfill is constructed in a coulee which extended from the crest of a north-south trending ridge southwestward toward Highway 200. Based on old aerial photographs, filling of the landfill began near the middle of the coulee and progressed both up and downhill. Prior to commencement of filling the area was grassland and did not show signs of groundwater discharge such as springs or long sinuous area of lush vegetation. Landfill cover consist of on-site soils which are placed and compacted daily. The working face rarely exceeds one-half acre.

Portions of the landfill area will be closed as space is occupied under 40 CFR Parts 257 and 258 Solid Waste Disposal Facility Criteria; Final Rule[1]. Where appropriate design criteria from the Federal Solid waste Disposal Facility Criteria Technical Manual[2] has been used in the preparation of this Run-on and Run-off Control Plan. This criteria requires that 25-year 24-hour run-on from areas adjacent to the landfill be prevented from draining onto the landfill area. Additionally, 25-year 24-hour run-off from the landfill area must be prevented from draining off the site.

The purpose of this plan is to: (1) control the 25-year 24-hour run-on volume so that it does not enter the active landfill area, (2) control the 25-year 24-hour run-off volume so that the past active area can be closed under the closure criteria, and (3) control the 25-year 24-hour run-off volume from the active landfill area.

Additionally, the retention ponds would be sized to contain run-off from the 100-year 24-hour design storm so that all runoff is retained on-site and the landfill can be exempted from the requirements of Storm Water General Permit administered by the Water Quality Bureau, Montana Department of Health and Environmental Sciences.

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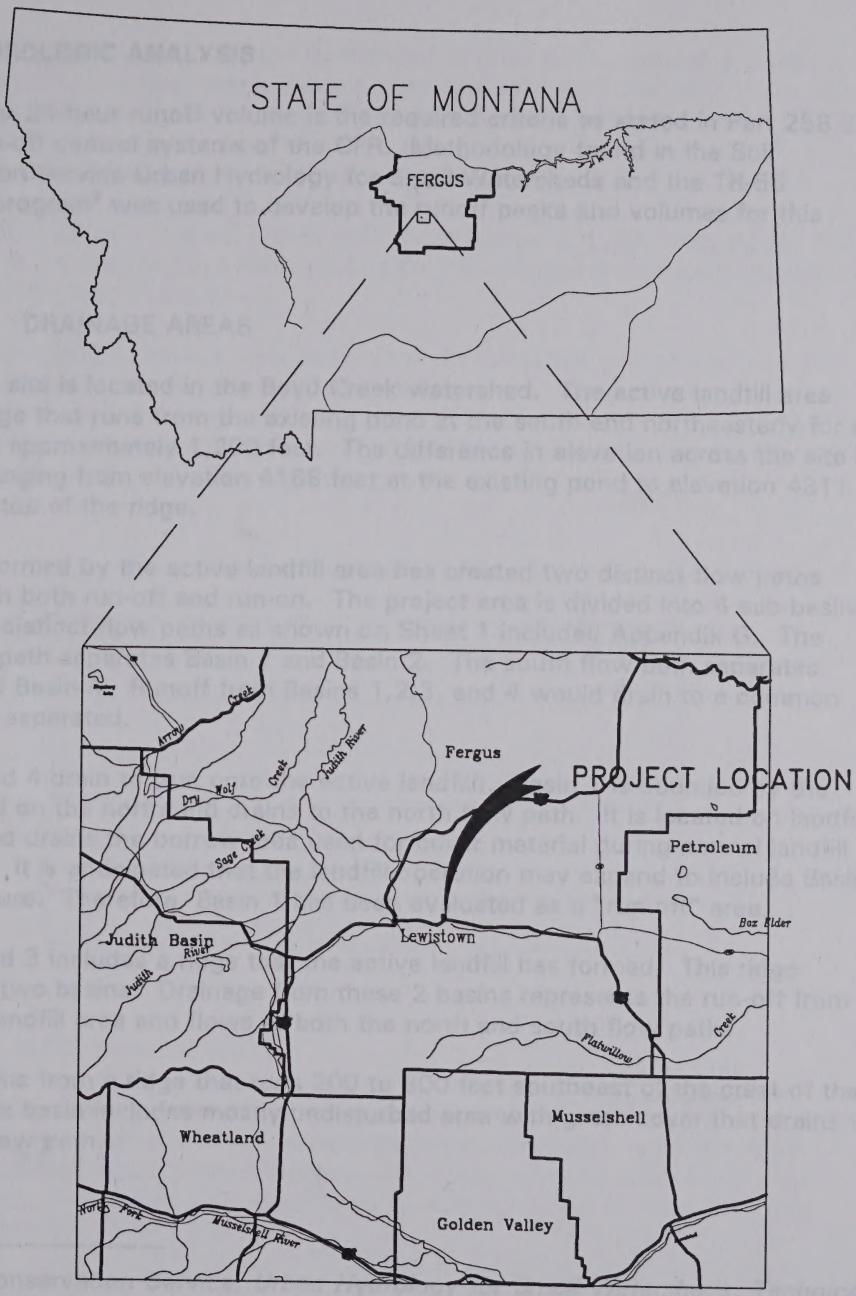
[1] Federal Register, *Part II, Environmental Protection Agency, 40 CFR Parts 257 and 258, Solid Waste Disposal Facility Criteria, Final Rule*, October 9, 1991.

[2] Environmental Protection Agency, *Solid Waste Disposal Facility Criteria Technical Manual*, November 1993.



MISTER M LANDFILL IS LOCATED APPROXIMATELY 3.5 MILES EAST OF LEWISTOWN, MONTANA OF U.S. HIGHWAY 287 IN SEC. 8, T15N, R19E.

FIGURE 1

VICINITY MAP

2 HYDROLOGIC ANALYSIS

The 25-year 24-hour runoff volume is the required criteria as stated in Part 258.25 Run-on/run-off control systems of the CFR. Methodology found in the Soil Conservation Service Urban Hydrology for Small Watersheds and the TR-55 computer program[3] was used to develop the runoff peaks and volumes for this analysis.

2.1 DRAINAGE AREAS

The landfill site is located in the Boyd Creek watershed. The active landfill area forms a ridge that runs from the existing pond at the south end northeasterly for a distance of approximately 1,200 feet. The difference in elevation across the site is 123 feet ranging from elevation 4188 feet at the existing pond to elevation 4311 feet at the top of the ridge.

The ridge formed by the active landfill area has created two distinct flow paths which catch both run-off and run-on. The project area is divided into 4 sub-basins by these 2 distinct flow paths as shown on Sheet 1 included Appendix G. The north flow path separates Basin 1 and Basin 2. The south flow path separates Basin 3 and Basin 4. Runoff from Basins 1,2,3, and 4 would drain to a common point if not separated.

Basins 1 and 4 drain to (run onto the active landfill). Basin 1 is bounded by the county road on the north and drains to the north flow path. It is located on landfill property and drains the borrow area used for cover material during normal landfill operations. It is anticipated that the landfill operation may expand to include Basin 1 in the future. Therefore, Basin 1 has been evaluated as a "run-off" area.

Basins 2 and 3 includes a ridge that the active landfill has formed. This ridge divides the two basins. Drainage from these 2 basins represents the run-off from the active landfill area and flows to both the north and south flow paths.

Basin 4 drains from a ridge that runs 200 to 300 feet southeast of the crest of the landfill. This basin includes mostly undisturbed area with grass cover that drains to the south flow path.

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[3] Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55 With Computer Program Version 2.0*, U.S. Department of Agriculture, Washington D.C., 1986

The 25-year 24-hour runoff volume is the required criteria as stated in Part 22.3 of Non-point-of-source control systems of the CFR. Metho-ology found in the Soil Conservation Service Urban Hydrology for Small Watersheds and the TR-55 computer program[a] was used to develop the runoff peaks and volumes for this analysis.

2.1 DRAINAGE AREAS

The landfill site is located in the Boyd Creek watershed. The active landfill area forms a ridge that runs from the existing base at the south end of the site a distance of approximately 1,200 feet. The difference in elevation across the site is 72 feet ranging from elevation 6,088 feet at the existing road to elevation 6,111 feet at the top of the ridge.

The ridge formed by the active landfill area has created two distinct flow paths which both run out of a run-on. The primary area is divided into 4 sub-basins by three a dividing flow paths as shown on Sheet 1 included Appendix D. The north flow path separates Basin 1 and Basin 2. The south flow path separates Basin 3 and Basin 4. Runoff from basins 1, 2, 3, and 4 drains to a common point in each separation.

Basins 1 and 4 drain to from zone the active landfill. Basin 1 is bounded by the county road on the north and drains to the northwest path. It is located on landfill property and drains through areas used for cover material during normal operations. It is anticipated that the landfill operation may expand to include basin 1 in the future. Therefore, Basin 1 has been evaluated as a "run-off" area.

Basins 2 and 3 include a ridge that the active landfill has formed. This ridge divides the two basins. Drainage from these 2 basins represents the run-off from the active landfill area and flows to both the north and south flow paths.

Basin 4 drains from a ridge that runs 200 to 300 feet southwest of the edge of the landfill. This basin includes mostly undisturbed area with grass cover that drains to the south flow path.

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[a] Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release 55 with Computer Program Version 2.0, U.S. Department of Agriculture, Washington D. C., 1986.

Basin 5 is a natural area that would be allowed to drain to the natural drainage (coulee) below the existing storm water pond. Natural runoff from this basin would not be allowed to come into contact with run-off from the active landfill.

Table 1 shows the drainage areas for each of the sub-basin areas.

A total of 16.0 acres of run-off would drain from Basins 1, 2, and 3 to Ponds 1 and 2. Basin 1 is not part of the existing active landfill area but is included because of the potential for future expansion.

A total of 5.8 acres of run-on from Basin 4 would be routed around the run-off facilities and drain to the natural drainage coulee.

A total of 11.7 acres of run-on from Basin 5 would be routed around the run-off facilities and drain to the natural drainage coulee.

TABLE 1: DRAINAGE AREAS

DRAINAGE BASIN	DRAINAGE AREA, acres
Basin 1	3.9
Basin 2	5.0
Basin 3	7.1
Basin 4	5.8
Basin 5	11.7

2.2 SOILS INFORMATION

Geology of the site is dominated by Cretaceous age sediments of the Kootenai Formation, abutted by Falls River sandstones to the north and west. Kootenai sediments includes shales and claystones with minor sandstone beds and one bentonite bed. The shales have weathered to moderately plastic silty clay over depths ranging from 5 to 20 feet.

Basin 5 is a natural area and would be allowed to drain to the natural drainage channel below the existing storm water pond. Partial runoff from this basin would not be allowed to come into contact with oil from the active landfill.

Table 1 shows the drainage areas for each of the sub-basin areas.

A total of 18.6 acres of run-off would drain from Basins 1, 2, and 3 to Ponds 1 and 2. Basin 1 is not part of the existing active landfill area but is included because of its potential for future expansion.

A total of 5.0 acres of run-on from Basin 4 would be routed around the run-off facilities and drain to the natural drainage course.

A total of 11.7 acres of run-on from Basin 5 would be routed around the run-off facilities and drain to the natural drainage course.

TABLE 1: DRAINAGE AREAS

DRAINAGE BASIN	DRAINAGE AREA acres
Basin 1	3.9
Basin 2	5.0
Basin 3	7.7
Basin 4	5.0
Basin 5	11.7

2.2 SOILS INFORMATION

Geology of the site is dominated by Cretaceous sediments of the Kootenai Formation, bounded by Tertiary River sediments to the north and west. Kootenai sediments include thin sandstones with minor conglomerate beds and one bentonite layer. The shales have weathered to moderately to highly clay soil depths ranging from 5 to 20 feet.

Hydrologic soils groups were determined from the Fergus County Soil Survey[4] and the hydrologic soils group listing published as part of TR-55. Soil in the area is described as Timberg-Castner complex located on slopes ranging from 0 to 45 percent. These soils falls within hydrologic soils group C and D. The analyses in this report were based upon a group D which would represent a minimum infiltration rate and maximum amount of runoff.

2.3 DESIGN STORM

A design storm with a 25-year recurrence interval and 24-hour duration was used for this investigation. The 24-hour rainfall amount was determined from the NOAA Atlas 2 for Montana[5] and equals 3.0 inches for the project area. The 100-year 24-hour design storm amount equals 3.8 inches.

The Soil Conservation Service has developed four storm distributions for different areas throughout the country. These distributions are identified as: Type I, Type IA, Type II or Type III storm distributions. Figure B-2 from TR-55 shows that the Lewistown area falls within the geographic boundary for a Type II distribution.

2.4 TIME OF CONCENTRATION

The time of concentration for each sub-basin was developed using hydrologic parameters for each sub-basin shown in Table 2 and Figure 15.2 from the Soil Conservation Service Hydrology Handbook[6]. Figure 15.2 uses the variables of slope and land use to develop a velocity of runoff. The time of concentration is determined by dividing the length of the flow path by the velocity within the TR-55 computer program. Figure 15.2 and the time of concentration for each sub-basin are shown in the computer output included in the Appendix.

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[4] Soil Conservation Service, *Soil Survey, Fergus County Montana*, U.S. Department of Agriculture in cooperation with Forest Service, Bureau of Land Management, and Montana Agricultural Experiment Station.

[5] National Weather Service, *NOAA Atlas 2, Montana, Isopluvials of 25-year, 24-hour Precipitation*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Silver Spring, Maryland, 1973.

[6] Soil Conservation Service, *National Engineering Handbook Section 4 Hydrology*, U.S. Department of Agriculture, Washington D.C., March 1985

TABLE 2: TIME OF CONCENTRATION

DRAINAGE BASIN	LONGEST FLOW LENGTH, feet	SLOPE, %	TIME OF CONCENTRATION, minutes
Basin 1	944	9.5	5.1
Basin 2	1,253	9.9	6.7
Basin 3	1,833	6.8	11.8
Basin 4	1,956	6.7	12.5
Basin 5	1,885	6.0	12.6

2.5 SNOW MELT POTENTIAL

Spring snow melt will also produce runoff that would fill the retention ponds. The energy budget method[7] of predicting snow melt runoff was used to evaluate the potential volume of snow melt runoff that would be produced. Snow melt runoff is produced by a combination of factors including snowpack, temperature, soil infiltration loss and wind speed. Insufficient data exists to predict a recurrence interval for snow melt runoff at the Mister M landfill. However, preliminary analysis indicate that a fairly severe snow melt event would produce runoff similar to the 25-year 24-hour design storm.

2.6 RUNOFF VOLUMES FOR DESIGN

2.6.1 25-Year 24-Hour

Table 3 presents the runoff from the 25-year 24-hour design storm. Output from the TR-55 computer analysis is included in the Appendix.

---

[7] Corps of Engineers, *Runoff from Snowmelt, Engineering Manual 1110-2-1406*, U.S. Army, Washington DC, 1960.

TABLE 2: TIME OF CONCENTRATION

DRAINAGE BASIN	LONGEST FLOW LENGTH, feet	SLOPE, %	TIME OF CONCENTRATION, minutes
Basin 1	944	0.6	5.1
Basin 2	1,223	3.3	8.7
Basin 3	1,033	5.8	11.5
Basin 4	980	8.7	12.5
Basin 5	1,383	8.5	12.6

2.6 SNOW MELT POTENTIAL

Spring snow melt will also produce runoff that would fill the retention ponds. The one-day budget method of analyzing snow melt runoff was used to evaluate the potential volumes of snow melt runoff that would be produced. Snow melt runoff is produced by a combination of factors, including snowpack, temperature, soil moisture, wind speed, and solar radiation. Insufficient data exists to predict a recurrence interval for snow melt runoff in the Alisso Mt basin. However, preliminary analysis indicates that a fairly severe snow melt event would produce runoff similar to the 25-year 24-hour design event.

2.8 RUNOFF VOLUMES FOR DESIGN

2.8.1 25-Year 24-Hour

Table 3 presents the output from the 25-year 24-hour design storm. Output from the HYSS computer analysis is included in the Appendix.

---

[7] Corps of Engineers, Army (now Engineers), Engineering Manual 1110-2-1420, U.S. Army, Washington DC, 1960.

TABLE 3: 25-YEAR 24-HOUR RUNOFF VOLUMES

DRAINAGE BASIN	RUNOFF VOLUME, cubic feet	RUNOFF VOLUME, acre-feet
Basin 1	16,138	0.3705
Basin 2	42,652	0.9790
Basin 3	60,566	1.3900
Basin 4	32,000	0.7350
Basin 5	64,600	1.4820

A total of 119,356 cubic feet or 2.7400 acre-feet of run-off from basins 1, 2, and 3 would drain to Ponds 1 and 2 during the 25-year 24-hour design storm. The maximum water surface elevation in Pond 1 would be about elevation 4195.0 feet and 4194.6 feet in Pond 2.

2.6.2 100-Year 24-Hour

The 100-year 24-hour design storm was also evaluated to determine whether the proposed retention basins would store that volume of runoff. By containing all of the 100-year runoff on-site, the landfill could be given an exemption from a General Storm Water Permit from the MDHES.

Table 4 presents the runoff from the 100-year 24-hour design storm. Output from the TR-55 computer analysis is included in the Appendix.

A total of 181,800 cubic feet or 4.1735 acre-feet of run-off from basins 1, 2, and 3 would drain to Ponds 1 and 2 during the 100-year 24-hour design storm. Ponds 1 and 2 have been sized to contain this volume of runoff. The maximum water surface elevation in Pond 1 and Pond 2 would be about elevation 4196.1 feet. The water surface elevations during the 100-year event would equalize in both ponds at this elevation.

TABLE 3: 25-YEAR 24-HOUR RUNOFF VOLUMES

ORIGINALE BASIN	RUNOFF VOLUME, cubic feet	RUNOFF VOLUME, acre-feet
Basin 1	16,766	0.3706
Basin 2	43,882	0.9760
Basin 3	60,384	1.3900
Basin 4	33,000	0.7580
Basin 5	64,810	1.4820

A total of 119,838 cubic feet and 2.7800 acre-feet of run-off from basins 1, 2, and 3 would drain to Pond 1 and 5 during the 25-year 24-hour cloudburst, thus maximizing water storage at evaporation in Pond 1 would be about elevation 4105.5 feet and 4106.6 feet in Pond 2.

2.6 100-year, 24-hour

The 100-year, 24 hour cloudburst was also evaluated to determine whether the proposed retention ponds would store the volume of runoff. By pondering all of the 100-year runoff solely the identical could be given an exemption from a General Orders Water Permit from the DPWES.

Table 4 presents the runoff from the 100-year/24 hour design storm. Outlines from the 18 sub-computer analyses is included in the Appendix.

A total of 231,400 cubic feet or 5.1773 acre-feet of run-off from basins 1, 2, and 3 would drain to Ponds 1 and 5 during the 100-year 24-hour design storm. Ponds 1 and 2 have been sized to contain the volume of runoff. The maximum water surface elevation in Pond 1 and Pond 2 would be about elevation 4106.1 feet. The water surface elevations during the 100-year event would approaches in both ponds at this elevation.

TABLE 4: 100-YEAR 24-HOUR RUNOFF VOLUMES

DRAINAGE BASIN	RUNOFF VOLUME, cubic feet	RUNOFF VOLUME, acre-feet
Basin 1	44,300	1.0173
Basin 2	56,800	1.3041
Basin 3	80,700	1.8519
Basin 4	46,300	1.0633
Basin 5	93,400	2.1450

3 PROPOSED STRUCTURAL IMPROVEMENTS

3.1 RUN-OFF FROM BASINS 1, 2 AND 3

3.1.1 Storage

Storm water from Basins 1, 2 and 3 represents run-off from the active landfill and proposed expansion area and would be retained in Ponds 1 and 2. The 25-year 24-hour design storm run-off from Basins 1, 2 and 3 would equal approximately 119,356 cubic feet or 2.7400 acre-feet. Peak flow during the 25-year 24-hour design storm from Basins 1, 2 and 3 would equal respectively; 14, 19 cfs and 21 cfs.

The storage curve for Pond 1 is shown on Table 5 and Figure 2. The storage curve for Pond 2 is shown on Table 6 and Figure 3. It is anticipated that Pond 1 would trap sediment conveyed during extremely heavy run-off events. The amount of sediment trapped and the volume of the pond would be monitored periodically. Sediment would be removed when it begins to encroach on the storage volume and effectiveness of the pond.

Run-off in excess of the capacity of Pond 1 would be conveyed to Pond 2 by a round 36 inch corrugated steel pipe. The inlet of the pipe would include a drop spillway structure with a crest elevation 3 feet above the bottom of Pond 1.

3.1.2 Pond Liner

Because Ponds 1 and 2 would store run-off water from the active landfill area, a pond liner would be used to eliminate deep percolation losses to the area groundwater.

3.1.2.1 Liner Material

The membrane liner recommended for the run-off retention basin is a buried flexible PVC liner. This liner material is the easiest to install and the most cost effective flexible liner material used in landfill retention basin applications. Typical retention basin design criteria for a PVC liner includes the following:

3. PROPOSED STRUCTURAL IMPROVEMENTS

3.1 RUN-OFF FROM BASINS 1, 2 AND 3

3.1.1 Storage

Storm water from Basins 1, 2 and 3 would be run-off from the newly landfilled and proposed expansion area and would be retained in Ponds 1 and 2. The 25-year, 24-hour design storm run-off from Basins 1, 2 and 3 would equal approximately 1,120,000 cubic yards or 2,240,000 acre-feet. Peak flow during the 25 year 24-hour design storm from Basins 1, 2 and 3 would equal respectively: 16, 19 cfs and 21 cfs.

The storage curve for Pond 1 is shown on Table 5 and Figure 2. The storage curve for Pond 2 is given on Table 6 and Figure 3. It is assumed that Pond 1 would receive run-off conveyed during extremely heavy run-off events. The amount of sediment trapped and the volume of the pond would be monitored periodically. Sediment would be removed when it begins to encroach on the storage volume and effectiveness of the pond.

Runoff in excess of the capacity of Pond 1 would be conveyed to Pond 2 by a recent 36 inch corrugated steel pipe. The inlet of the pipe would include a drop spillway structure with a crest elevation 3 feet above the bottom of Pond 1.

3.1.2 Pond Liner

Because Ponds 1 and 2 would store run off water from the active landfill area, a pond liner would be used to eliminate deep percolation from leaves to the area groundwater.

3.1.2.1 Liner Material

The membrane liner recommended for the run-off retention basin is a buried flexible PVC liner. This liner material is the easiest to install and the most cost effective flexible liner material used in lagoon and retention basin applications. Typical basin design criteria for a PVC liner includes the following:

TABLE 5: POND 1 CHARACTERISTICS

DEPTH ft	WSE ft	TOP WIDTH ft	TOP LENGTH ft	SURFACE AREA sf	INC VOL cf	TOT VOL cf	TOT VOL cy	TOT VOL a-f
0	4192	65.00	65.00	4,225	0	0	0	0.0
0.5	4192.5	68.00	68.00	4,624	2,212	2,212	82	0.05
1	4193	71.00	71.00	5,041	2,416	4,629	171	0.11
1.5	4193.5	74.00	74.00	5,476	2,629	7,258	269	0.17
2	4194	77.00	77.00	5,929	2,851	10,109	374	0.23
2.5	4194.5	80.00	80.00	6,400	3,082	13,191	489	0.30
3	4195	83.00	83.00	6,889	3,322	16,514	612	0.38
3.5	4195.5	86.00	86.00	7,396	3,571	20,085	744	0.46
4	4196	89.00	89.00	7,921	3,829	23,914	886	0.55
4.5	4196.5	92.00	92.00	8,464	4,096	28,010	1,037	0.64
5	4197	95.00	95.00	9,025	4,372	32,383	1,199	0.74
5.5	4197.5	98.00	98.00	9,604	4,657	37,040	1,372	0.85
6	4198	101.00	101.00	10,201	4,951	41,991	1,555	0.96
6.5	4198.5	104.00	104.00	10,816	5,254	47,245	1,750	1.08
7	4199	107.00	107.00	11,449	5,566	52,812	1,956	1.21
7.5	4199.5	110.00	110.00	12,100	5,887	58,699	2,174	1.35
8	4200	113.00	113.00	12,769	6,217	64,916	2,404	1.49

TABLE 6: POND 2 CHARACTERISTICS

DEPTH ft	WSE ft	TOP WIDTH ft	TOP LENGTH ft	SURFACE AREA sf	INC VOL cf	TOT VOL cf	TOT VOL cy	TOT VOL a-f
0	4191	75.00	317.00	23,775	0	0	0	0.0
0.5	4191.5	78.00	320.00	24,960	12,184	12,184	451	0.28
1	4192	81.00	323.00	26,163	12,781	24,965	925	0.57
1.5	4192.5	84.00	326.00	27,384	13,387	38,351	1,420	0.88
2	4193	87.00	329.00	28,623	14,002	52,353	1,939	1.20
2.5	4193.5	90.00	332.00	29,880	14,626	66,979	2,481	1.54
3	4194	93.00	335.00	31,155	15,259	82,238	3,046	1.89
3.5	4194.5	96.00	338.00	32,448	15,901	98,138	3,635	2.25
4	4195	99.00	341.00	33,759	16,552	114,690	4,248	2.63
4.5	4195.5	102.00	344.00	35,088	17,212	131,902	4,885	3.03
5	4196	105.00	347.00	36,435	17,881	149,783	5,548	3.44
5.5	4196.5	108.00	350.00	37,800	18,559	168,341	6,235	3.86
6	4197	111.00	353.00	39,183	19,246	187,587	6,948	4.31
6.5	4197.5	114.00	356.00	40,584	19,942	207,529	7,686	4.76
7	4198	117.00	359.00	42,003	20,647	228,176	8,451	5.24
7.5	4198.5	120.00	362.00	43,440	21,361	249,536	9,242	5.73
8	4199	123.00	365.00	44,895	22,084	271,620	10,060	6.24

MISTER M LANDFILL

RETENTION POND 1

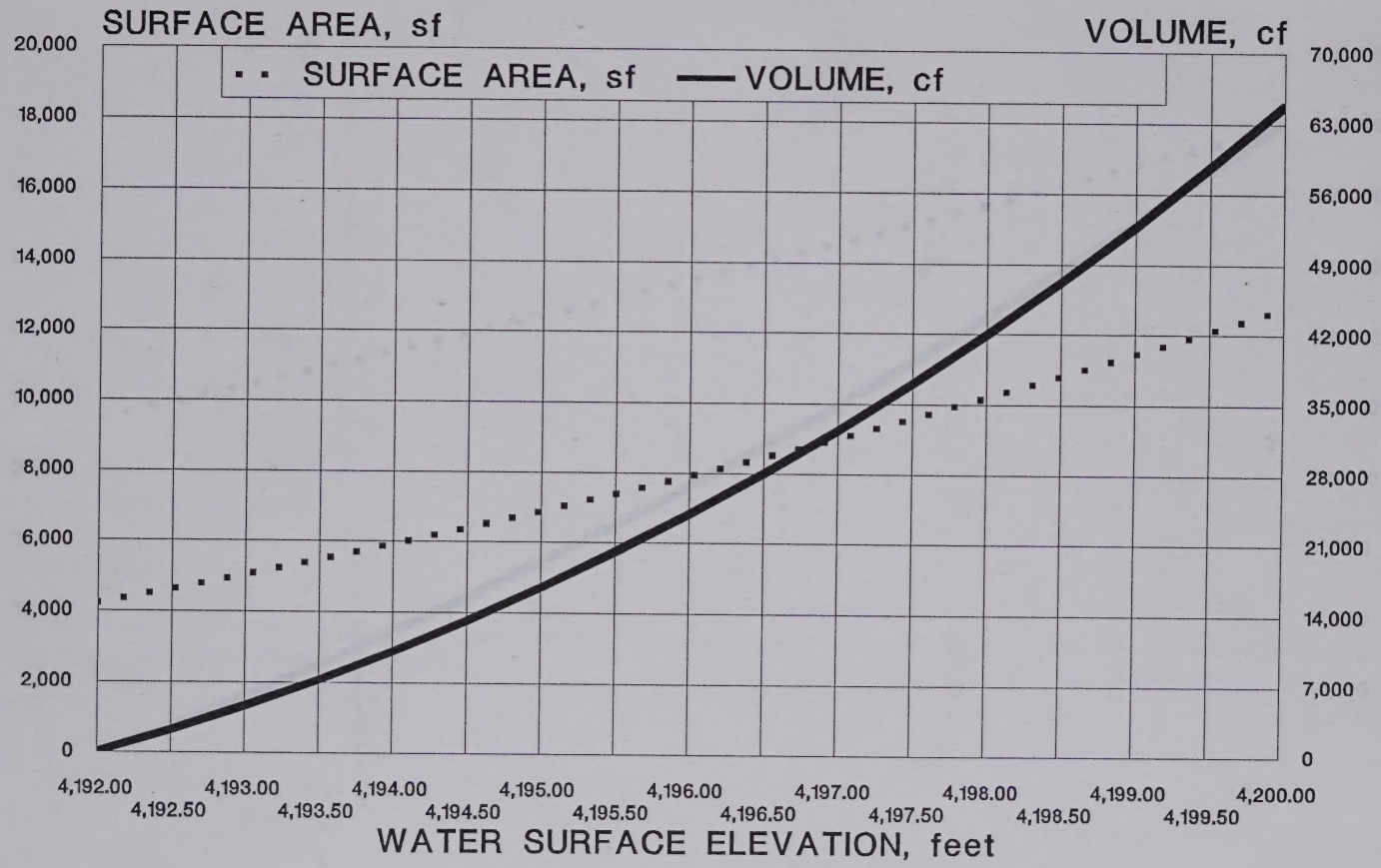
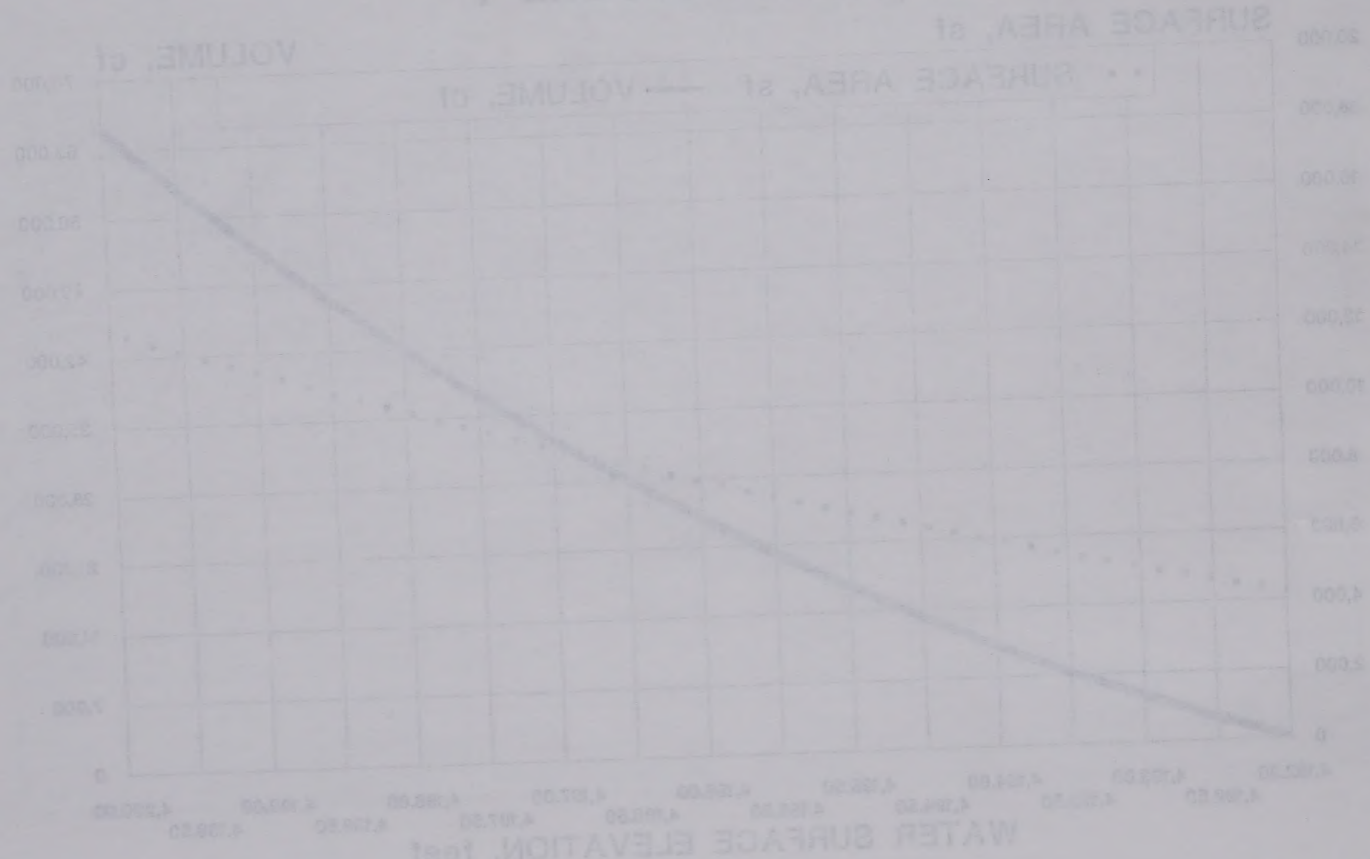


FIGURE 2



MISTER M LANDFILL

RETENTION POND 2

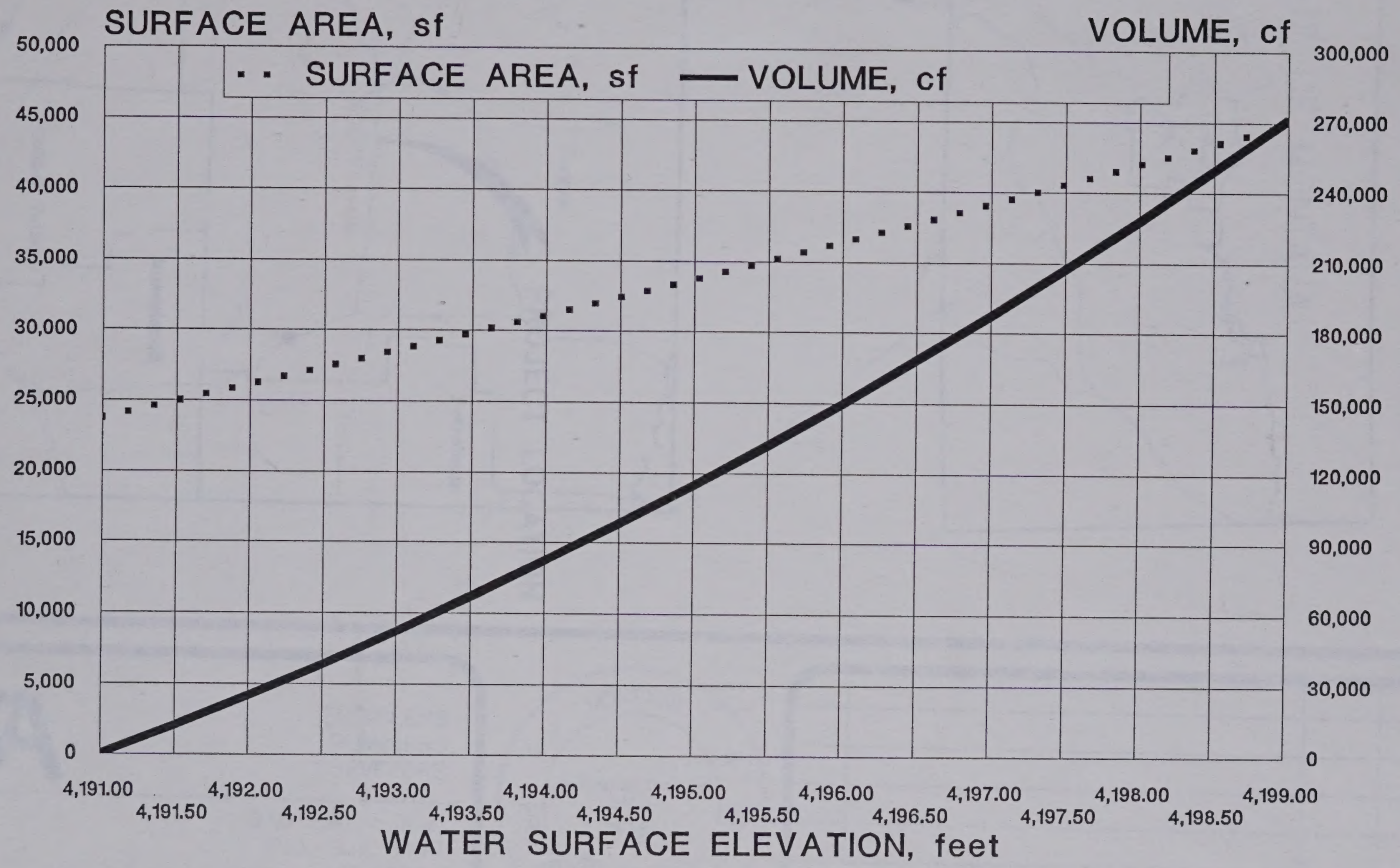
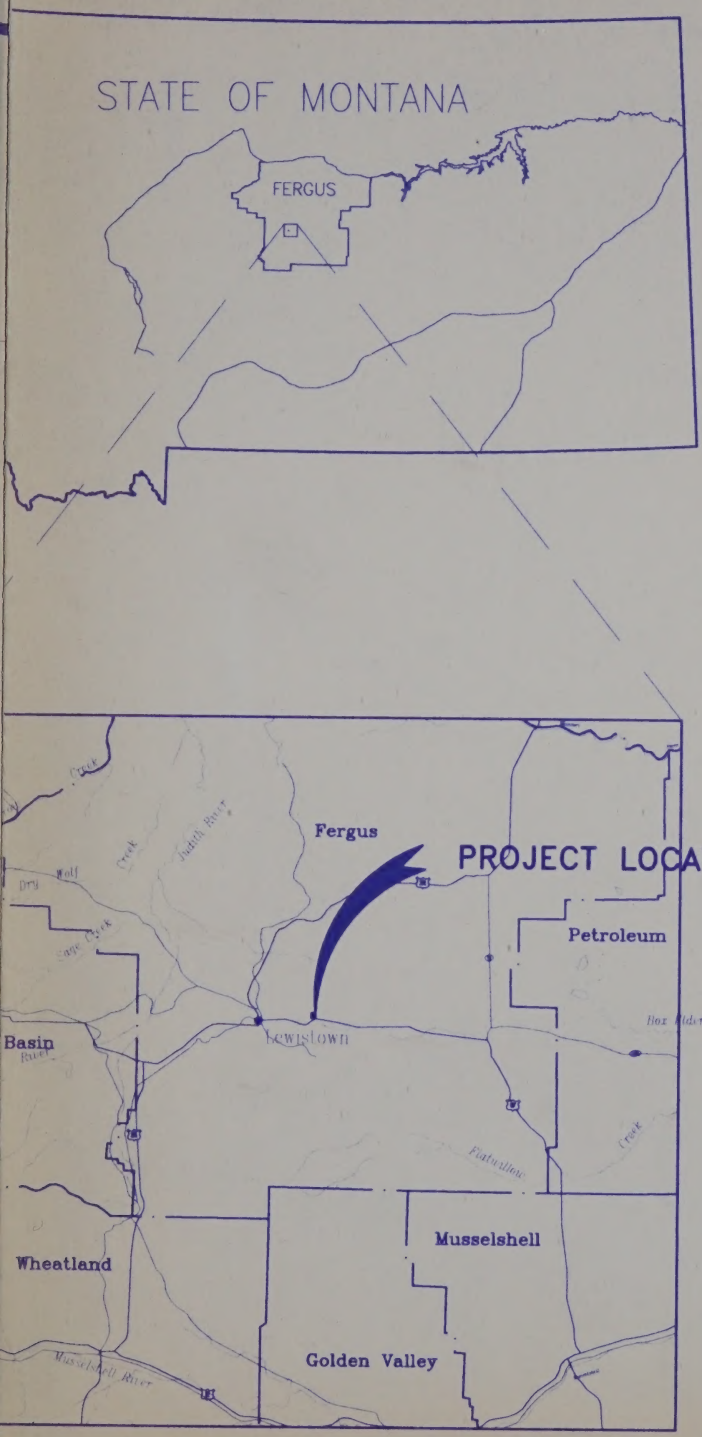


FIGURE 3



VICINITY MAP

NO.	DESCRIPTION	DATE	BY:

REVISIONS

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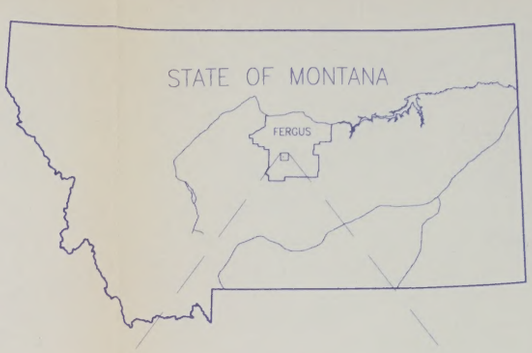
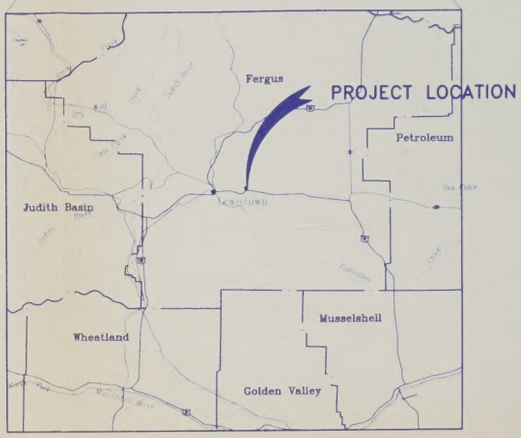
RUN-ON/RUN-OFF CONTROL FOR MISTER M LANDFILL

/RUN-OFF CONTROL PLAN
R MISTER M LANDFILL





VICINITY MAP

NO SCALE

MISTER M LANDFILL IS LOCATED APPROXIMATELY 3.5 MILES EAST OF LEWISTOWN, MONTANA OF U.S. HIGHWAY 287 IN SEC. 8, T15N, R19E.

SHEET INDEX

SHEET 1 ..... VICINITY MAP, SITE PLAN
SHEET 2 ..... RETENTION PONDS 1 & 2
SHEET 3 ..... ROAD PLAN & PROFILE
SHEET 4 ..... MISCELLANEOUS DETAILS
SHEET 5 ..... MISCELLANEOUS DETAILS

COPY

LEGEND

- PROPOSED RETENTION POND
- ACTIVE LANDFILL AREAS
- DRAINAGE BASIN BOUNDARY
- LONGEST FLOW PATH
- PROPOSED CONTOURS
- EXISTING CONTOURS
- × 3054.6 EXISTING SPOT GRADES

NO.	DESCRIPTION	DATE	BY:

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DRAWN BY: JMH
CHK'D. BY: MAF
APPR. BY: KWS
DATE: 1/95
Q. A. PEER REVIEW MAF

RUN-ON/RUN-OFF CONTROL PLAN FOR MISTER M LANDFILL
LEWISTOWN, MONTANA

SITE PLAN AND INDEX SHEET

PROJECT NUMBER
2729.002-010-0112

SHEET NUMBER
1

M LANDFILL IS LOCATED APPROXIMATELY 3.5 MILES EAST OF
OWN, MONTANA OF U.S. HIGHWAY 287 IN SEC. 8, T15N, R19E.

SHEET INDEX

ET 1 ..... VICINITY MAP, SITE PLAN

ET 2 ..... RETENTION PONDS 1 & 2

ET 3 ..... ROAD PLAN & PROFILE

ET 4 ..... MISCELLANEOUS DETAILS

ET 5 ..... MISCELLANEOUS DETAILS

COPY

LEGEND

PROPOSED RETENTION POND

ACTIVE LANDFILL AREAS

DRAINAGE BASIN BOUNDARY

LONGEST FLOW PATH

PROPOSED CONTOURS

EXISTING CONTOURS

× 3054.6 EXISTING SPOT GRADES

Morrison Maierle/
SINCE 1945

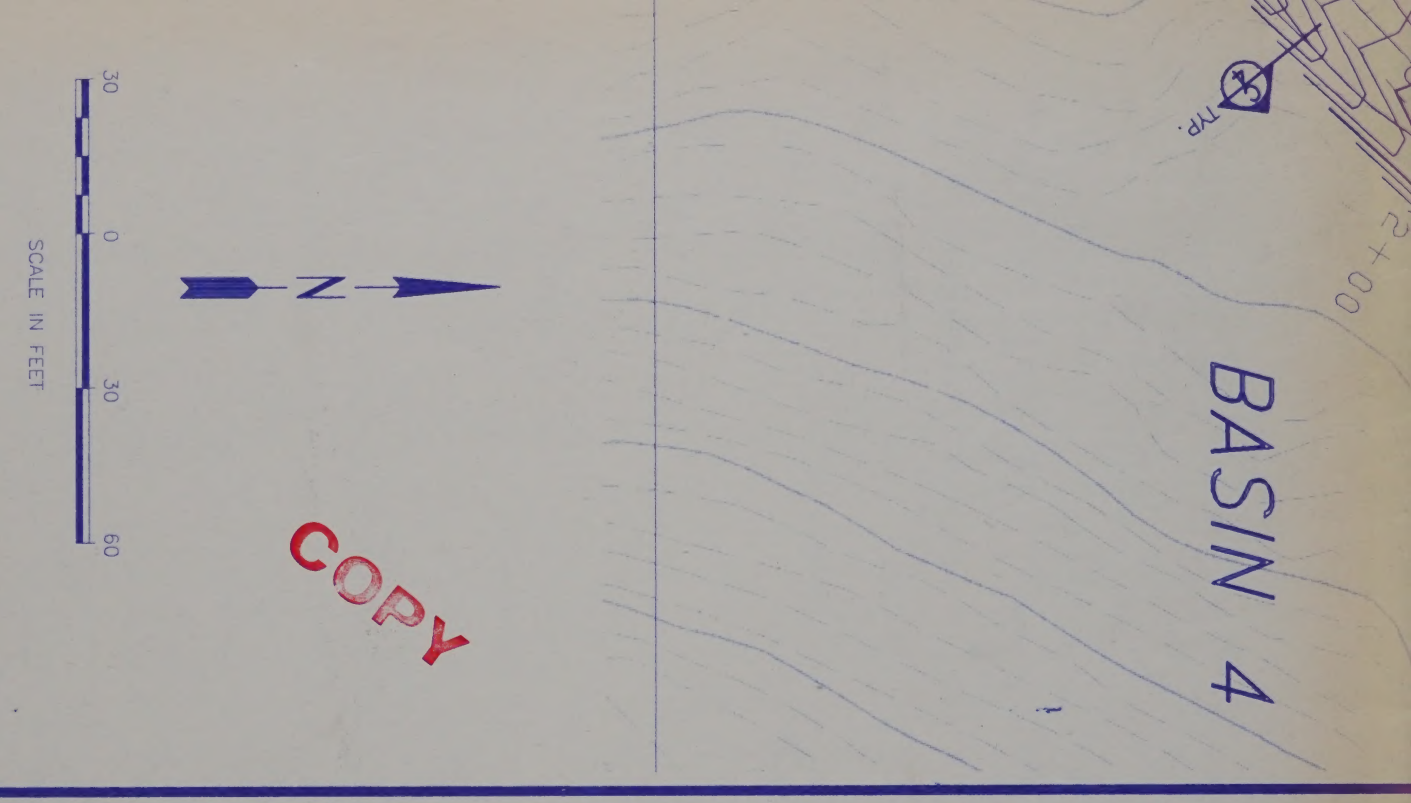
DRAWN BY: JMH
CHK'D. BY: MAF
APPR. BY: KWS
DATE: 1/95
Q. A.
PEER REVIEW MAF

RUN-ON/RUN-OFF CONTROL PLAN
FOR
MISTER M LANDFILL
LEWISTOWN, MONTANA

SITE PLAN AND INDEX SHEET

PROJECT NUMBER
2729.002-010-0112

SHEET NUMBER
1



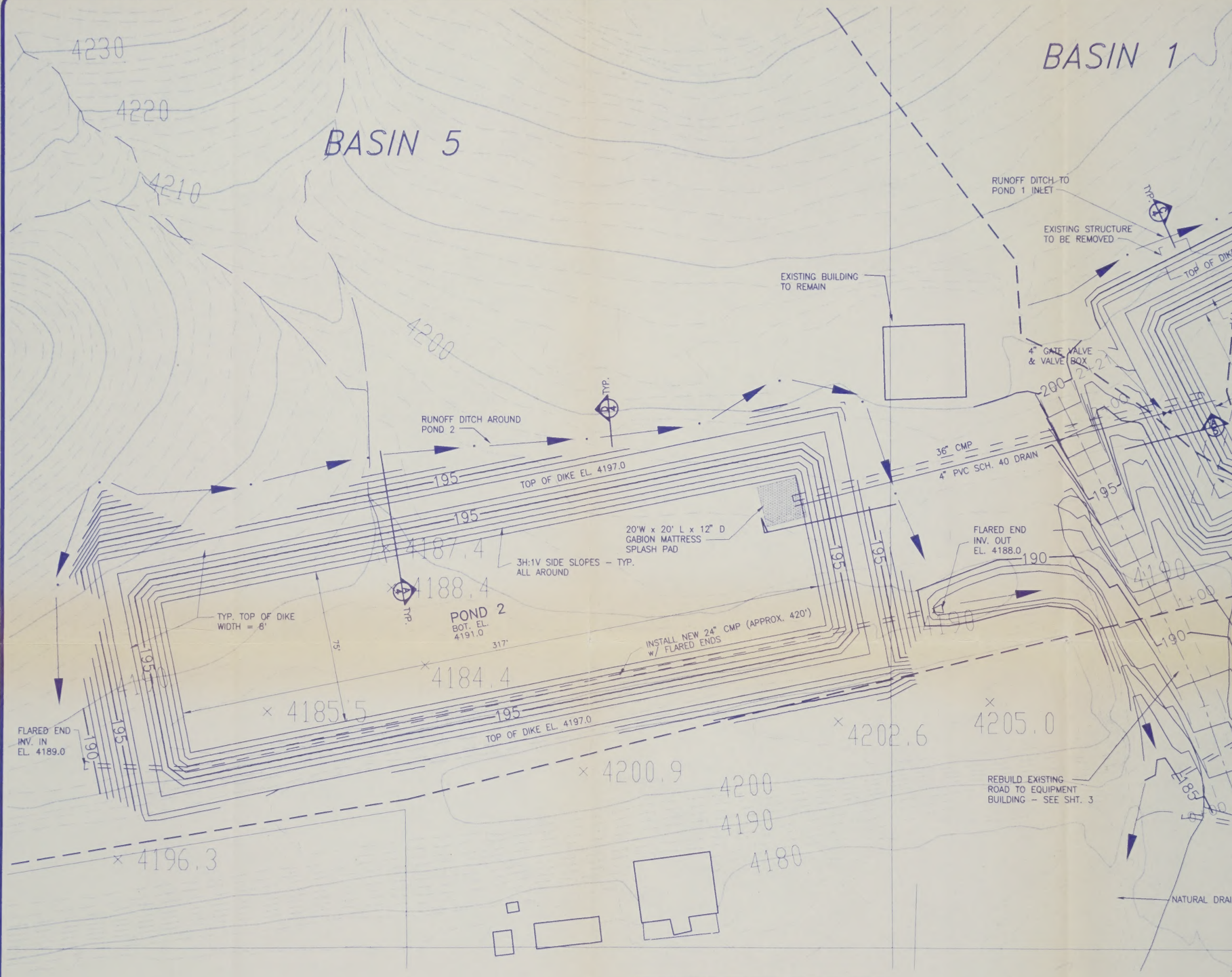
PROJECT NUMBER
2729.002-010-0112
SHEET NUMBER
2

RUN-ON/RUN-OFF CONTROL PLAN
FOR
MISTER M LANDFILL
LEWISTOWN, MONTANA

RETENTION PONDS 1 & 2

DRAWN BY: JMH
CHK'D. BY: MAF
APPR. BY: KWS
DATE: 1/95
Q. A.
PEER REVIEW MAF

Morrison
Maierle/
SINCE 1945



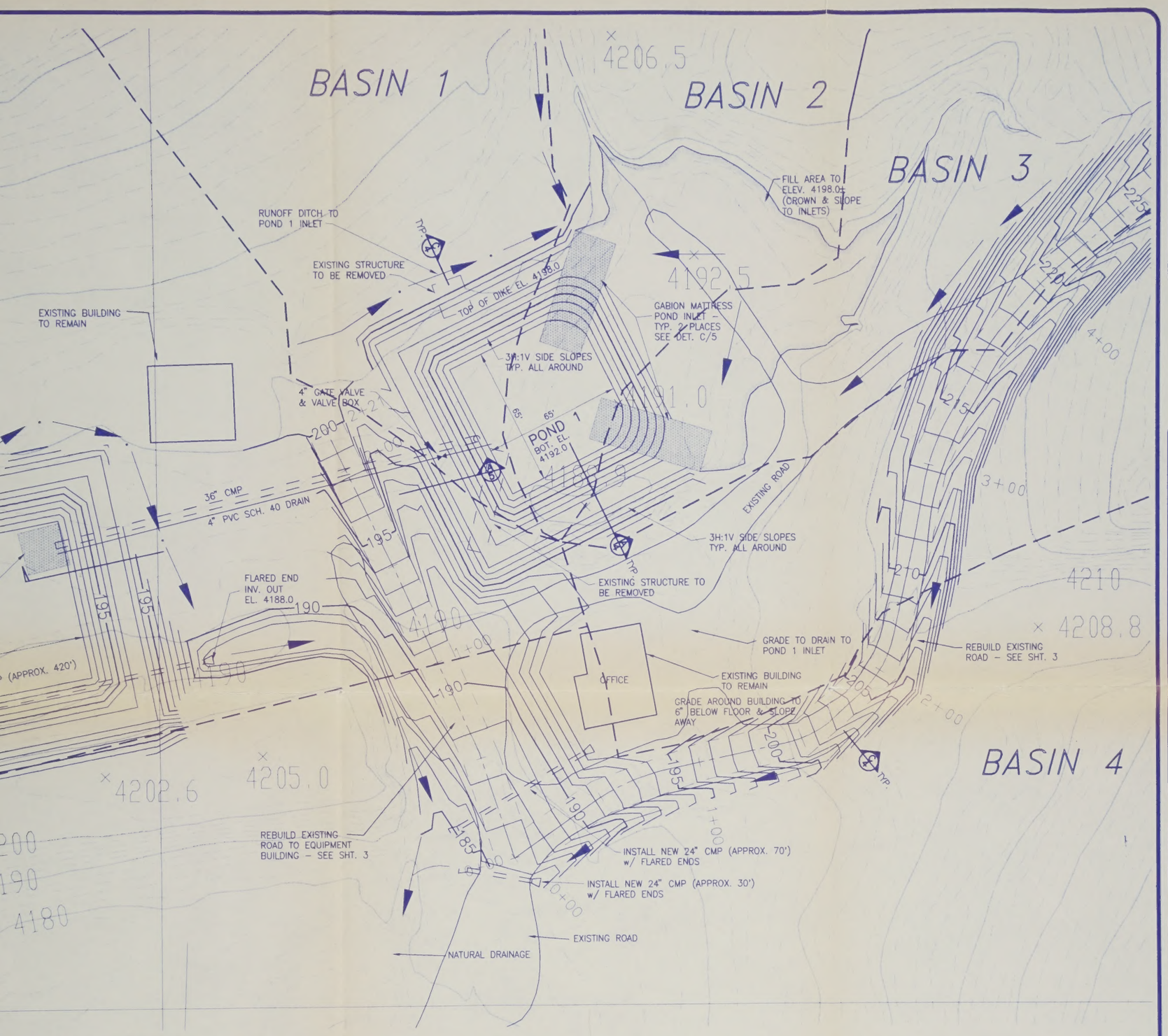
LEGEND

EXISTING CONTOUR

FINISHED CONTOUR

RUNOFF DITCH

OFFICE BENCHMARK COORDINATES		
CORNER	EASTING	NORTHING
NE	7226.8667	10181.1333
NW	7198.4000	10176.1333
POND 1 BOTTOM COORDINATES		
CORNER	EASTING	NORTHING
NE	7195.3054	10329.2346
NW	7138.0556	10300.6243
SE	7224.9875	10272.382
SW	7167.1126	10242.4806
POND 2 BOTTOM COORDINATES		
CORNER	EASTING	NORTHING
NE	6953.9544	10230.2127
NW	6643.1042	10168.0744
SE	6968.6559	10156.6677
SW	6657.8057	10094.5295



BENCHMARK COORDINATES	
EASTING	NORTHING
7226.8667	10181.1333
7198.4000	10176.1333
BOTTOM COORDINATES	
EASTING	NORTHING
7195.3054	10329.2346
7138.0556	10300.6243
7224.9875	10272.382
7167.1126	10242.4806
2 BOTTOM COORDINATES	
EASTING	NORTHING
6953.9544	10230.2127
6643.1042	10168.0744
6968.6559	10156.6677
6657.8057	10094.5295

COPY

NO.	DESCRIPTION	DATE	BY:
	REVISIONS		

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Q. A. PEER REVIEW MAF

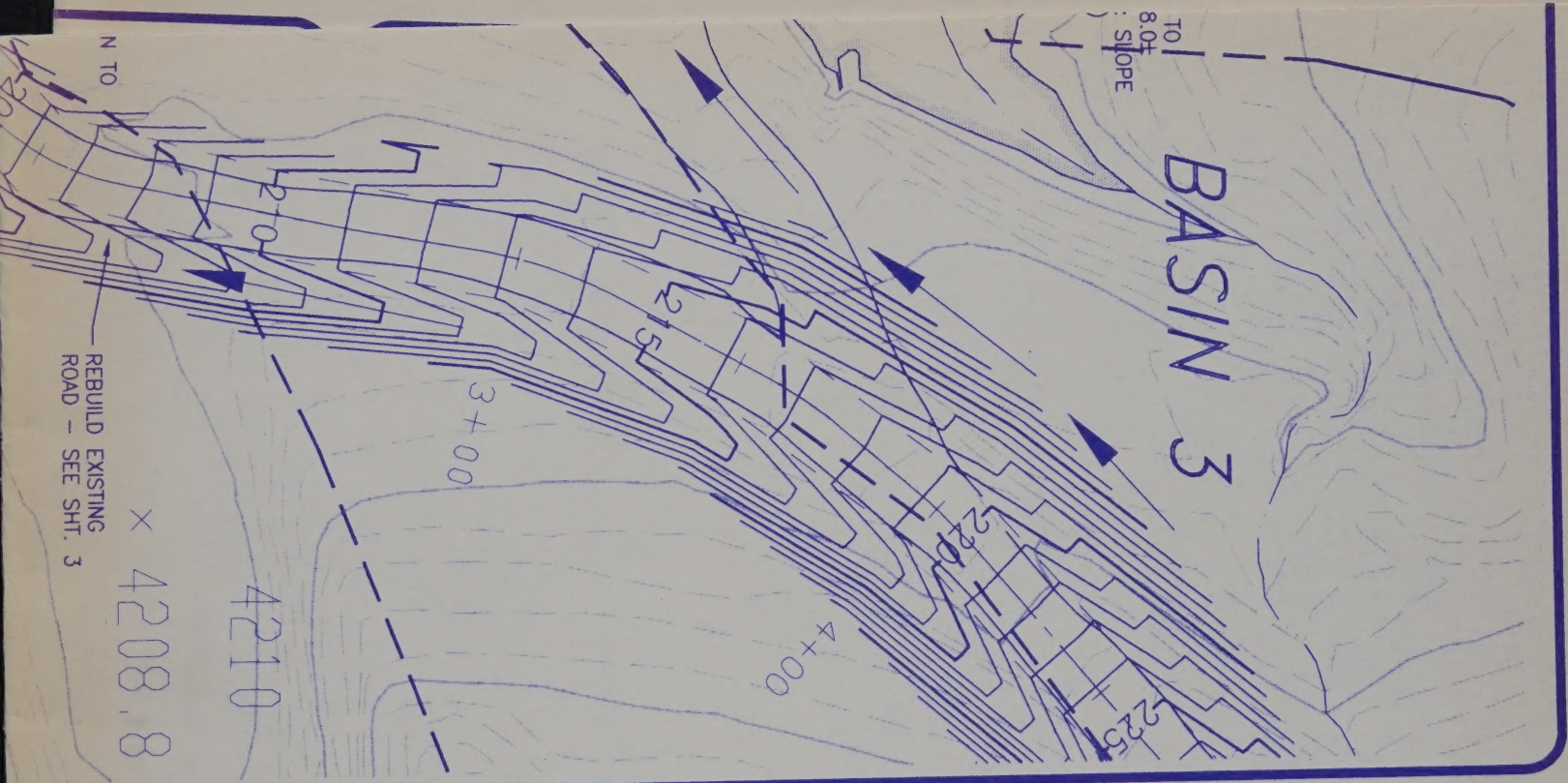
RUN-ON/RUN-OFF CONTROL PLAN FOR MISTER M LANDFILL

LEWISTOWN, MONTANA

RETENTION PONDS 1 & 2

PROJECT NUMBER
2729.002-010-0112

SHEET NUMBER
2



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MONTANA
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NO.	DESCRIPTION	DATE	BY:

REVISIONS

- Maximum side slopes for the basin shall be 3H to 1V.
- Recommend 60 mil liner (30 mil liner would be adequate).
- Subgrade rolled to provide smooth, planar surface with no objects creating point loads on the liner material.
- 8 oz/square foot non-woven geotextile fabric underneath for cushion over rocky soils.
- 12 inch minimum cover is recommended.
- 5% slack provided in the liner to allow movement for settlement, etc.

It is not anticipated that leachate would come into contact with the storm water runoff. The presence of leachate would be monitored as part of the normal landfill operations plan. If leachate seeps were found, then they would be contained separately from storm water runoff and disposed of as discussed in Best Management Practices in chapter 4 (section 4.5).

If a rare set of circumstances did allow leachate to come into contact with the storm water, the leachate should not pose a problem to the PVC liner material[8]. PVC does have the ability to resist landfill leachate constituents. Test results on PVC samples exposed to leachate showed that there is negligible change in the physical properties. This is due to relatively low concentrations of dissolved materials in the leachate, under 2%, and because most of the dissolved materials do not affect the properties of plastic linings. Leachate is not a solvent and should not absorb the plastic materials of the PVC.

3.1.2.2 Installation

Correct installation of the flexible PVC liner is essential to assure the integrity of the liner. The surface on which the liner is to be placed shall be reasonably smooth, free of holes, depressions, and projections. Large rocks, 8 inches and larger shall be removed and rocks smaller than 8 inches shall be rolled into the subgrade with appropriate compaction equipment. A smooth, planar surface would be provided without objects that would create a point load on the PVC liner material.

A cushion layer consisting of an 8 oz/square foot non-woven geotextile fabric shall be laid over the prepared subgrade to provide a cushion between the PVC liner and the subgrade. The cushion fabric shall be installed with the lap requirements

---

[8]Plastic Liners for Sanitary Landfills, Mr. Guy A. Goethner and Dr. Charles E. Staff, Staff Industries, Inc., Upper Montclair, New Jersey, October 19, 1977.

recommended by the manufacturer. Upon placement of the cushion fabric, the PVC liner shall be laid and field welded per the manufacturer's recommendations. PVC is sensitive to ultraviolet light since the light evaporates the plasticizer. Therefore, it is recommended that the liner have a soil cover at a minimum depth of 12 inches to protect it from ultraviolet light, and accidental puncture.

The pond liner would be constructed by stripping existing vegetation including grasses and trees. The liner would cover the bottom of Pond 1 at elevation 4192 feet and Pond 2 at elevation 4191 feet. The liner extend up to an elevation of 4197 feet in Pond 1 and 4196 feet in Pond 2 to provide 2 feet of freeboard. The topsoil and organic material removed would be stockpiled for later use at the landfill.

An 18 inch layer of soil would be placed to protect the PVC pond liner. The protective layer would be constructed in layers 6 to 9 inches thick compacted by 2 passes of spreading equipment. A 6 inch layer of organic material from the composting operation would be placed as the final layer to promote the establishment of wetlands vegetation.

3.1.3 Water Balance

Water stored in the proposed retention pond would be lost to evaporation and consumptive use by plants. Net evaporation loss would be approximately 26 inches per year. Consumptive use would be approximately 23 inches per year for a total 49 inches per year.

It is proposed that the run-off would be treated passively and consumed by the establishment of native and wetlands vegetation in the pond bottoms. It is also proposed that any water in excess of evaporation and consumptive use would be used for the following purposes: (1) dust control within the landfill site, (2) spray irrigation within the landfill site and (3) for the composting operation. If there were excess water above these uses, then it could be transported to an approved wastewater treatment facility for disposal. The use of run-off water for dust control, spray irrigation and composting would require periodic testing of the water for suitability and the presence of leachate (see Chapter 4 for BMP to isolate leachate from storm water). If for some unforeseen reason leachate was detected, then the storm water would be disposed at the City of Lewistown waste water treatment facility.

3.1.4 Dike

Dikes would be constructed around Pond 1 to a crest elevation of 4198 feet and

around Pond 2 to 4197 feet as shown on Sheet 2 in the Appendices. The dike section would consist of a 8 foot wide crest, 3H:1V upstream slope, 3H:1V downstream slope and a cutoff trench under the embankment. A geotechnical stability analysis of a maximum embankment section is included in Appendices to demonstrate the slope stability under various conditions.

The native soil materials meeting CL or CH soil classification would be used to construct the dike embankment. The dike sub grade would be stripped of vegetation and disked up to prepare for placement of the fill layers. A sub grade layer 6 to 12 inches thick would be compacted to a density of not less than 90% of the maximum Modified Proctor within ±3% of optimum moisture, uniformly incorporated, as determined by ASTM D1557. The dike embankment would be constructed using 6-9 inch lifts and compacted using heavy equipment such as sheepsfoot rollers to compact to a density of not less than 90% of the maximum Modified Proctor. Rocks larger than 1/2 the height of the lift would not be allowed. Any rocks meeting this requirement would be blended into the soil matrix to avoid a layer or pocket of rocks.

3.1.5 Pipe From Pond 1 to Pond 2

Run-off in excess of the capacity of Pond 1 would be conveyed to Pond 2 by a 36 inch corrugated steel pipe (CSP). The landfill road would be constructed to provide 3 feet of cover over this pipe. The inlet of the pipe would include a drop spillway structure with a crest elevation 3 feet above the bottom of Pond 1.

A 4 inch diameter PVC line would be installed parallel to the 36 inch CSP to provide a means to drain Pond 1 to Pond 2. This pipe would allow water levels to be controlled in both ponds and would allow Pond 1 to be drained for sediment removal (as required).

3.1.6 Drainage Swales and Ditches

Drainage from the landfill closure slopes in Basins 1, 2 and 3 would be directed into Pond 1 using drainage ditches and swales. The ditch section would consist of a 4 foot bottom width, 3H:1V side slopes, 2 foot minimum depth and a minimum transverse slope of 0.4%. Minimum capacity at 1 foot of depth would equal 20 cfs and maximum capacity at 2 foot of depth would equal 75 cfs. The transverse slope ranges up to 10% which could produce velocities ranging up to 6 fps. These velocities will require the establishment of a heavy vegetative cover as specified in section 3.1.7 and/or erosion control measures such as straw bales as discussed in Chapter 4. Control of erosion will require periodic inspection and maintenance:

(1) to assure that erosion is being controlled.
(2) to remove any sediment accumulations and vegetation growth.
(3) to repair any erosion damage and to install, where required, additional erosion control measures discussed in Chapter 4.

3.1.7 Revegetation and Seeding

The disturbed areas above the pond bottom would be seeded with a seed mixture per Table 5 as recommended by the Soil Conservation Service.

TABLE 7: RECOMMENDED SEED MIXTURE

GRASS MIXTURE	DRILLED, lbs per acre	HYDROSEEDING, lbs per acre
Thickspike wheatgrass	4	8
Western wheatgrass	4	8
Slender wheatgrass	1	2
Green needlegrass	1	2
TOTAL	10	20

Where possible, a firm weed free seed bed would be prepared with up to 4 inches of topsoil. A fertilizer application of 30 pounds of actual nitrogen would be made prior to seeding. Drilled seeding would be preferred over hydroseeding.

Drilled seeding would be done twice with the second operation done at an angle to the first operation. The recommended seeding rate would be maintained by seeding 1/2 of the seed during each operation.

Hydroseeding would be recommended on slopes too steep for drilling operations. A mulch slurry would be applied with a tracer at a rate of 4,000 pounds per acre. Approximately 500 pounds per acre would be applied with the seeding mix and 3,500 pounds per acre would be applied after the hydroseeding operation as cover.

Fertilizer would be applied following the seeding operation at the rate of 100 pounds of 16-20-0 (nitrogen-phosphorous-potassium) per acre. A 34-0-0 fertilizer application would be applied in the year following seeding.

(1) To assure that grass is being controlled.

(2) To remove any equipment, cumulithion and vegetative growth.

(3) To repair any erosion damage prior to travel, where required, additional erosion control measures should be considered in advance.

5.1.7 Operation and Scheduling

Operations at the advanced treatment stations should be guided with a seed mixture Table 3 as recommended by the Soil Conservation Service.

TABLE 3: RECOMMENDED SEED MIXTURE

GRASS MIXTURE	ORGANIC, lb per acre	HYDROSEEDING, lb per acre
Tall wheatgrass	4	6
Western wheatgrass	4	6
Crested wheatgrass	1	2
Green needlegrass	1	2
TOTAL	10	20

[illegible] preferable, a lean weed free seed bed would be prepared with up to 4 inches [illegible] (without supplementation of 65 pounds of nitrogen) would be made [illegible] to seeding. Diked seeding would be preferred over hydroseeding.

[illegible] seeding would be done twice when the second operation is at an angle to the first one effect. The recommended seeding rate would be determined by [illegible] 1/2 of the seed during each operation.

[illegible] would be recommended on slopes less than 10% for cutting operations [illegible] would be applied with a rate of 4,000 pounds per acre, [illegible] 300 pounds per acre and to yield with the seedbed mix and [illegible] 00 pounds per acre should be applied after the hydroseeding operation as cover.

[illegible] would be applied following the seeding operation at the rate of 1 100 [illegible] of 1:2:0 6 (nitrogen phosphate potassium) fertilizer per acre. A 34-0-0 fertilizer [illegible] would be applied in the year following seeding.

The pond bottom would be prepared for the establishment of wetlands vegetation by the following means:

(1) Following the preparation of the sub-grade stockpiled topsoil and landfill compost materials would be placed on all disturbed areas associated with wetlands development to a minimum depth of 6 inches.

(2) Seeding and planting would then follow.

(3) Following the placement of topsoil, salvaged aquatic soils and vegetation including cattails, sedges, and rushes would be spread over the pond bottom at a rate of approximately 10 to 20 cubic yards per acre. Existing wetlands areas must not be disturbed by this operation.

(4) All topsoil areas and seeded areas would be fertilized at a rate of 40 pounds of nitrogen per acre and 40 pounds of phosphate per acre.

(5) Periodic monitoring of the types of vegetation established will be required to determine whether undesirable deep-rooted plants are being established that would compromise the PVC liner. These types of vegetation would be removed before they became substantial in size and could damage the liner. If a substantial deep-rooted plant did become established, it would be removed and the liner inspected in that area for integrity.

3.2 RUN-ON FROM BASINS 4 AND 5

Storm water from Basin 4 and 5 would be prevented from coming into contact with run-off from the active landfill area. Run-on from Basins 4 and 5 would be prevented from mixing with run-off water from Basins 1, 2 and 3 by a system of drainage swales and ditches which would divert the water around Ponds 1 and 2. This runoff would be allowed to drain naturally to Boyd Creek.

Peak flow during the 25-year 24-hour design storm from Basins 4 and 5 would equal respectively; 11 cfs and 25 cfs. Peak flow during the 100-year 24-hour design storm from Basins 4 and 5 would equal respectively; 16 cfs and 32 cfs.

3.2.1 Drainage Swales and Storm Drain Piping

Drainage from Basins 4 and 5 would be directed around Ponds 1 and 2 using drainage swales and storm drain piping. The ditch sections would include a

minimum 4 foot bottom width, 3H:1V side slopes, 2 foot minimum depth and a minimum transverse slope of 0.4%. The minimum ditch capacity at 1 foot of depth would equal 20 cfs and 75 cfs at 2 foot of depth. The transverse slope averages 7% which could produce velocities up to 6 fps. These velocities will require the establishment of a heavy vegetative cover and/or erosion control measures discussed in Chapter 4.

Control of erosion will require periodic inspection and maintenance:

(1) to assure that erosion is being controlled.
(2) to remove any sediment accumulations and vegetation growth.
(3) to repair any erosion damage and to install, where required, additional erosion control measures discussed in Chapter 4.

A 24 inch storm drain pipe would be required to convey run-on which is trapped behind Pond 2. This storm drain pipe would run under Pond 2 and discharge to the natural swale draining the site. The natural swale is the historic point of discharge for the run-on water from Basins 4 and 5.

3.2.2 Revegetation and Seeding

The disturbed areas above the pond bottom would be seeded as described in Section 3.1.7.

4 STORM WATER EROSION CONTROL MEASURES AND BEST MANAGEMENT PRACTICES (BMP'S)

This chapter will discuss different methods of reducing erosion of the earthen slopes, earth-lined channels, and disturbed areas within the landfill from storm water runoff and controlling any leachate seeps that may surface.

Erosion control guidelines have been published by the Montana Department of Health and Environmental Sciences (MDHES)[9]. Best Management Practices (BMP'S) recommended for the Mister M Landfill are discussed in the following sections and would be used, where applicable, during the normal landfill operations. Additionally, the use of control berms, outlet protection, and sediment ponds are incorporated in the design shown on sheets 1 and 2.

4.1 FILTER FENCE EROSION CONTROL

Definition:

This BMP consists of constructing a silt fence which serves as a temporary sediment barrier as shown in Appendix F. It would consist of a filter fabric stretched and attached to supporting posts. Wire fence backing is necessary. There are several types of filter fabric in common use. Silt fences assist in sediment control by retaining some of the eroded soil particles and slowing the runoff velocity to allow particle settling in the ponded area.

Purpose: The purpose of the filter fence includes the following:

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Advantages:

1. Downstream riparian properties will not be damaged by sediment deposits originating from the development.

---

[9] Montana Department of Health and Environmental Sciences, Water Quality Bureau, Montana Sediment and Erosion Control Manual, Helena, Montana, May 1993.

STORM WATER EROSION CONTROL MEASURES AND BEST MANAGEMENT PRACTICES (BMP S)

This chapter will discuss different methods of reducing erosion of the earthen shores, stream-bed channels, and disturbed areas within the land fill from storm water runoff and controlling any leachate seepage that may occur.

Erosion control guidelines have been established by the Montana Department of Health and Environmental Sciences (MDHES). Best Management Practices (BMPS) recommended for the Miles M Landfill are discussed in the following sections and should be used, where applicable, during the normal landfill operations. Adjacent to the use of control berms, cover protection, and sediment ponds are incorporated in the design shown on drawings 1 and 2.

4.1 FILTER SERVICE EROSION CONTROL

Purpose:

This BMP consists of constructing a silt fence which serves as a temporary filtering barrier as shown in Appendix F. It would consist of a later fabric fence and attached to supporting posts. With fence cleaning is necessary, due to several types of filter fabric, a common type. Silt fences assist in sediment control by retaining some of the eroded soil particles and allowing the water only to flow through particle settling in the ponded area.

Procedure:

The procedure of the filter fence includes the following:

To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.

To decrease the velocity of sheet flow and low-to-moderate level channel flows.

Advantages:

Downstream riparian properties will not be damaged by sediment deposits originating from the developed area.

---

[1] Montana Department of Health and Environmental Sciences, Water Quality Bureau Montana Sediment and Erosion Control Manual, Helena, Montana, May 1983.

2. Sediment will not cause damage to fish habitat.

Disadvantages:

1. Filter fences are not practical where large flows of water are involved, hence the need to restrict their use to drainage areas of one acre or less and flow rates of less than 0.5 cfs and only used for special circumstances.

2. Problems may arise from incorrect selection of pore size and/or improper installation.

Design Criteria:

Silt fences should be applied with the following design constraints:

- Drainage area of 1 acre or less or in combination with sediment basin in a larger site.
- Maximum slope steepness (normal (perpendicular) to fence line) 1H:1V.
- Maximum sheet or overland flow path length to the fence of 100 feet. (intermediate fences on slopes are necessary if slope lengths exceed 100 feet).
- Limit concentrated flows to no greater than 0.5 cfs.
- Provided undisturbed buffer zones of 3-5 feet between silt fences and surface waters to allow safe removal.

The selection of a filter fabric is based on soil conditions at the construction site (which affect the equivalent opening size (EOS) fabric specification) and characteristics of the support fence (which affect the choice of tensile strength). The designer shall specify a filter fabric that retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging. The following criteria is recommended for selection of the equivalent opening size.

1). If 50% or less of the soil, by weight, will pass the U.S. standard sieve No. 200, then select the EOS to retain 85 percent of the soil. The EOS should not be finer than EOS 70.

2). For all other soil types, the EOS should be no larger than the openings in the Standard Sieve No. 70 [0.0083 in. or 0.21 mm] except where direct discharge to a stream, lake or wetland will occur, then the EOS shall be no larger than Standard Sieve No. 100.

To reduce the chance of clogging, it is preferable to specify a fabric with openings as large as allowed by the criteria. No fabric should be specified with an EOS

Subdrains will not require recharge to function.

Underdrain Design:

Filter fences are not practical where large flows of water are involved. Hence use need to require their use to drainage areas of one acre or less and for slopes of less than 0.5 cfs and only used for special circumstances.

Problems may arise from incorrect selection of pore size and/or improper installation.

Design Criteria:

Filter fences should be applied with the following design considerations:

Drainage area of 1 acre or less or in combination with sediment basin in a larger site.

Maximum slope steepness (horizontal to vertical) 1:1.

Maximum sheet or overland flow path to the fence of 100 feet.

Minimum fence or slope distance necessary if slope length exceeds 100 feet.

Limit concentrated flow to no greater than 0.5 cfs.

Provided adequate overland flow zones of 3-5 feet between silt fences are available to allow sediment deposition.

Selection of a filter fabric is based on soil conditions at the construction site. Specifically, the soil's percent passing the 200 (EOS) sieve, erosion susceptibility characteristics of the soil, normal flow velocity, the site of a fence alignment, and distance and gradient of a filter fence that retains the soil behind the fence. Fabrics with low EOS will have difficulty in passing enough to prevent fabric ponding and overtopping. The following criteria is recommended for selection of the appropriate fabric.

If EOS is 15 or less of the soil by weight, will pass the U.S. standard sieve no. 200, then select the EOS to retain 85 percent of the soil. The EOS should not be larger than EOS 70.

For all other soil types, the EOS should be no larger than the opening in the Standard Sieve No. 70 (0.0083 in. or 0.21 mm) except where direct discharge to a stream, lake or wetland will occur, then the EOS shall be no larger than standard sieve No. 100.

Because the chance of clogging, it is preferable to specify a fabric with opening sizes as allowed by the criteria. No fabric should be specified with an EOS

smaller than U.S. Standard Sieve No. 100 [0.0059 in. or 0.14 mm]. If 85 percent or more of a soil, by weight, passes through the openings in a No. 200 sieve [0.0029 in. or 0.074 mm], then filter fabric shall not be used. Most of the particles in such a soil would not be retained if the EOS was too large, and they would clog the fabric quickly if the EOS was small enough to capture the soil.

4.2 MULCHING AND MATTING EROSION CONTROL

Definition:

This BMP consists of applying plant residues or erosion control blankets to the soil surface on steep slopes as shown in Appendix F.

Purpose:

To provide immediate protection to exposed soils during the period of short construction delays or over winter months through the application of plant residues, or other suitable materials.

Mulches also enhance plant establishment by conserving moisture and moderating soil temperatures. Mulch helps hold fertilizer, seeds, and topsoil in place in the presence of wind, rain, and runoff and maintains moisture near the soil surface.

Applications:

- In areas which have been seeded either for temporary or permanent cover, mulching should immediately follow seeding.
- Areas which cannot be seeded because of the season or are otherwise unfavorable for plant growth.
- In an area of greater than 2:1 slope, mulching should immediately follow seeding.

Advantages:

1. Mulching offers instant protection to exposed areas.
2. Mulches conserve moisture and reduce the need for irrigation.

Disadvantages:

1. Care must be taken to apply mulch at the specified thickness and on steep slopes mulch must be supplemented with netting.
2. Thick mulches can reduce the soil temperature, delaying seed germination.

ller than U.S. Standard Sieve No. 100 (0.0059 in. or 0.14 mm), 81.85 percent more of a soil, by weight, passes through the opening in a No. 200 sieve (0.029 in. or 0.074 mm), then fine fabric strip fabric used. Most of the particles such a soil would not be retained in the ESS was too large, and they would enter when placed in the ESS was small enough to capture the soil.

4.2 MULCHING AND MATTING EROSION CONTROL

Mulch

A Mulch consists of applying plant residues or erosion control blankets to the soil surface on steep slopes as shown in Appendix B.

Uses

Provides immediate protection to exposed soils during the period of short temporary delay, or over winter months, through the application of plant residues, or other erosion control materials.

Helps later entrance plant establishment by conserving moisture and moderating temperatures. Mulch helps hold fertilizer, seeds, and topsoil in place in the presence of wind, rain, and runoff, and moderates temperatures at the soil surface.

Advantages

In areas which have been seeded either for temporary or permanent cover, mulching should extend the growing season.

Allows water to be added because of the shade or moisture was only to the plant growth.

In an area of erosion plant cover, a slope, mulching should immediately halting erosion.

Disadvantages

Mulching offers instant protection to exposed areas.

Mulches conserve moisture and reduce the need for irrigation.

Advantages

Care must be taken to apply mulch at the specified thickness and on steep slopes mulch must be anchored with netting.

Thick mulches can reduce the soil temperature, delaying seed germination.

4.3 STRAW BALES EROSION CONTROL

Definition:

This BMP consists of constructing a temporary sediment barrier by using a row of entrenched and anchored straw bales as shown in Appendix F. Straw bale barriers are temporary erosion control measures that may be used for either sheet-flow or concentrated flow applications. Straw bale barriers may be used as silt traps, check dams, and to protect inlet structures.

Purpose:

1. To intercept and detain small amounts of sediment from disturbed areas of limited extent to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Applications:

Straw bale barriers should be applied under the following design constraints:

- Below disturbed areas subject to sheet and rill erosion.
- Where the size of the drainage area is no greater than 1/4 acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet and the maximum slope gradient behind the barrier is 50 percent (2H:1V).
- In minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres.
- Where effectiveness is required for less than 3 months.
- Under no circumstances should straw bale barriers be constructed in live streams, swales or drainages.

Straw bale barriers often prove ineffective at erosion control due to poor installation and maintenance practices. Care in installation and periodic maintenance greatly increases the effectiveness of this control measure. Even when properly installed, straw bale barriers are not usually as effective as silt fences or gravel berms. Straw bales used in conjunction with other controls may improve removal efficiencies and durability.

Advantages:

1. When properly used, straw bale barriers are an inexpensive method of

sediment control.

Disadvantages/Problems:

1. Straw bale barriers are easy to misuse and can become contributors to a sediment problem instead of a solution.

2. It is difficult to tell if bales are securely seated and snug against each other.

4.4 TERRACING EROSION CONTROL

Definition:

This BMP consists of establishing a soil surface with a rough appearance on slopes a shown in Appendix F. The horizontal depressions are created by machinery and/or control of final grading. All slopes steeper than 3:1, and greater than 5 vertical feet would benefit from roughening and either stair-step grading, grooving, or furrowing prior to seeding. Slope roughening with tracked equipment may provide protection from erosion on a temporary basis. Generally, slopes steeper than 2H:1V should be stair-stepped with benches at sufficient width to retain sediment eroded from the slope above.

Purpose:

To reduce erosion damage by intercepting surface runoff and conveying it to a stable outlet at a non-erosive velocity.

Applications:

Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance.

Advantages:

Gradient terraces slow the velocity of runoff, increase the distance of overland flow and reduce effective hydraulic gradient. They also hold moisture and minimize sediment.

Disadvantages:

May significantly increase cut and fill costs and cause sloughing if excessive water

sediment control.

Groyne fields behind groynes are easy to manage and can become contributors to the sediment problem instead of a solution.

It is difficult to tell if water are actually eroding and acting against each other.

4.4 TERRACING PROBLEM CONTROL

Groyne:

Many examples of groyne building a soil surface with a lower angle on slopes shown in Appendix F. The horizontal dykes above are created by hand digging for control and tilled planting. All slopes steeper than 3:1, and greater than 2 meters, would benefit from terracing and in either cases they are very good, grass and allowing water to seep. Slope terracing with trees and shrubs may provide protection from erosion on a temporary basis. Eventually, stick-and-wedge or 2ft TV sections can be constructed with benches as a unit with which to retain sediment eroded from the slope above.

Groyne:

Groyne structures disrupt by interception or a force current and conveying it to a single outlet at a non-damaging velocity.

Interceptors:

Silent terraces commonly are limited to diversion and having a water outlet system. They should not be constructed on deep soils or on soils that are too dry, steep, or shallow to permit practical and economical installation and maintenance.

Groyne:

Silent terraces slow the velocity of runoff, increase the infiltration of overland flow and reduce obstacles by small gradients. They also hold a certain amount of water.

Conveyance:

Is significantly increased, cut and fill costs and causes sloughing of overhanging water

infiltrates soils.

4.5 LEACHATE SEEP CONTROL

It is not anticipated that leachate would be allowed to come into contact with the storm water runoff. The presence of leachate would be monitored as part of the normal landfill operations plan. If leachate seeps were found, then they would be contained separately from storm water runoff and disposed of at the City of Lewistown waste water treatment facility.

A simple BMP is included in Appendix F to capture any leachate seeps that may surface and isolate that water from storm water runoff. The leachate would be pumped out of the containment structure when it reaches eight-tenths of the total depth and disposed of at an approved facility.

APPENDICES

APPENDIX A - SOILS INFORMATION

APPENDIX B - NOAA ATLAS

APPENDIX C - TR-55 COMPUTER OUTPUT

APPENDIX D - MISCELLANEOUS COMPUTATIONS

APPENDIX E - GEOTECHNICAL STABILITY ANALYSIS

APPENDIX F - EROSION CONTROL METHODS

APPENDIX G - DESIGN SHEETS 1 TO 5

APPENDIX A

SOILS INFORMATION

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In cooperation with
United States Department
of Agriculture, Forest
Service; United States
Department of the Interior,
Bureau of Land Management;
and Montana Agricultural
Experiment Station

Soil Survey of Fergus County, Montana

yellowish brown silty clay about 12 inches thick. ark yellowish brown shale is at a depth of about 37 nches. Depth to shale ranges from 20 to 40 inches.

Permeability of the Timberg soil is slow. Available water capacity is low to moderate. Effective rooting lepth is 20 to 40 inches. The average annual wetting lepth where this soil is under native vegetation is 20 to 6 inches. Runoff is rapid, and the hazard of water erosion is high. The hazard of soil blowing is high.

The Castner soil is shallow and well drained. It formed n residuum derived dominantly from fractured hard sandstone. Typically, the surface layer is grayish brown stony loam about 7 inches thick. The underlying material s pale brown very channery loam about 7 inches thick. Light gray sandstone is at a depth of about 14 inches. Depth to sandstone ranges from 10 to 20 inches.

Permeability of the Castner soil is moderate. Available water capacity is very low. Effective rooting depth is 10 to 20 inches. The average annual wetting depth where this soil is under native vegetation is 10 to 20 inches. Runoff is rapid, and the hazard of water erosion is high. The hazard of soil blowing is moderate.

The soils in this unit are used as rangeland.

These soils are poorly suited to cultivated crops and to hay and pasture because of steepness of slope and rough topography.

The potential plant community on the Timberg soil is mainly bluebunch wheatgrass, green needlegrass, western wheatgrass, and Idaho fescue. If the range is excessively grazed, the proportion of most of these plants decreases and the proportion of Idaho fescue, plains reedgrass, Sandberg bluegrass, and blue grama increases. If excessive grazing continues, plants such as broom snakeweed, Kentucky bluegrass, perennial weeds, and annuals may invade. The potential plant community produces about 2,300 pounds of air-dry vegetation in years of above-normal precipitation and 1,700 pounds in years of below-normal precipitation.

The potential plant community on the Castner soil is mainly rough fescue, bluebunch wheatgrass, plains muhly, and green needlegrass. If the range is excessively grazed, the proportion of these plants decreases and the proportion of Idaho fescue, blue grama, needleandthread, and prairie junegrass increases. If excessive grazing continues, plants such as Kentucky bluegrass, clubmoss, perennial weeds, and annuals may invade. The potential plant community produces about 1,200 pounds of air-dry vegetation in years of above-normal precipitation and 800 pounds in years of below-normal precipitation.

The suface layer of these soils is susceptible to water erosion and soil blowing if it is disturbed or if the range is overgrazed. The soils are not suited to mechanical treatment because of steepness of slope and rough topography.

These soils are not suited to windbreaks. They are limited mainly by slope.

The main limitations for homesite development on the Timberg soil are slow permeability, slope, moderate depth to shale, shrink-swell potential, and low soil strength. The soil is severely limited for septic tank absorption fields because of slope, slow permeability, and moderate depth to shale. Cuts to level building sites can expose shale. Shrinking and swelling and low soil strength can damage roadbeds and road surfaces. Adequate drainage and the use of suitable fill material that is properly compacted can overcome these limitations. In the construction of basements or foundations for dwellings, the shrink-swell potential can be overcome by backfilling excavations with suitable material that has low shrink-swell potential.

The main limitations for homesite development on the Castner soil are slope, shallow depth to sandstone, potential frost action, and content of rock fragments. The soil is severely limited for septic tank absorption fields because of slope and shallow depth to sandstone. Cuts to level building sites can expose sandstone. Frost action can damage roadbeds and road surfaces. Adequate drainage and the use of suitable fill material that is properly compacted can overcome this limitation. Removal of pebbles and cobbles in disturbed areas is needed for best results when landscaping, particularly in areas used for lawns.

This map unit is in capability subclass VIIe, nonirrigated. The Timberg soil is in Clayey range site, 15- to 19-inch precipitation zone, and the Castner soil is in Shallow range site, 15- to 19-inch precipitation zone.

243—Tomty complex, 4 to 25 percent slopes. This map unit is on foot slopes in the southern part of the county. Slopes commonly are 250 to 1,000 feet long. Elevation is 4,600 to 5,500 feet. The average annual precipitation is about 22 inches, the average annual air temperature is about 42 degrees F, and the average frost-free period is about 100 days.

This unit is about 50 percent Tomty silty clay and 30 percent Tomty silty clay loam.

Included in this unit are small areas of soils that are similar to these Tomty soils but are 40 to 60 inches deep over shale. Also included are small areas of moderately deep Castle soils and deep Lipke soils. Included areas make up about 20 percent of the total acreage.

The Tomty silty clay is deep and somewhat poorly drained. It formed in colluvium and alluvium derived dominantly from shale. Typically, the surface layer is black silty clay about 6 inches thick. The upper 12 inches of the subsoil is very dark gray and dark gray silty clay and clay, and the lower 12 inches is light gray silty clay. The upper 10 inches of the substratum is gray clay, and the lower part to a depth of 60 inches or more is gray and light gray silty clay.

The Tomty silty clay loam is deep and somewhat poorly drained. It formed in colluvium and alluvium derived dominantly from shale. Typically, the surface

depth is 20 to 40 inches. The average annual wetting depth where this soil is under native vegetation is 20 to 26 inches. Runoff is rapid, and the hazard of water erosion is high. The hazard of soil blowing is high.

The Castner soil is shallow and well drained. It formed in residuum derived dominantly from fractured hard sandstone. Typically, the surface layer is grayish brown channery loam about 7 inches thick. The underlying material is pale brown very channery loam about 7 inches thick. Light gray sandstone is at a depth of about 14 inches. Depth to sandstone ranges from 10 to 20 inches.

Permeability of the Castner soil is moderate. Available water capacity is very low. Effective rooting depth is 10 to 20 inches. The average annual wetting depth where this soil is under native vegetation is 10 to 20 inches. Runoff is medium, and the hazard of water erosion is high. The hazard of soil blowing is moderate.

The soils in this unit are used as rangeland.

These soils are poorly suited to cultivated crops and to hay and pasture because of rough topography and shallow depth to sandstone in the Castner soil.

The potential plant community on the Timberg soil is mainly bluebunch wheatgrass, green needlegrass, western wheatgrass, and Idaho fescue. If the range is excessively grazed, the proportion of most of these plants decreases and the proportion of Idaho fescue, plains reedgrass, Sandberg bluegrass, and blue grama increases. If excessive grazing continues, plants such as broom snakeweed, Kentucky bluegrass, perennial weeds, and annuals may invade. The potential plant community produces about 2,300 pounds of air-dry vegetation in years of above-normal precipitation and 1,700 pounds in years of below-normal precipitation.

The potential plant community on the Castner soil is mainly rough fescue, bluebunch wheatgrass, plains muhly, and green needlegrass. If the range is excessively grazed, the proportion of these plants decreases and the proportion of Idaho fescue, blue grama, needleandthread, and prairie junegrass increases. If excessive grazing continues, plants such as Kentucky bluegrass, clubmoss, perennial weeds, and annuals may invade. The potential plant community produces about 1,200 pounds of air-dry vegetation in years of above-normal precipitation and 800 pounds in years of below-normal precipitation.

These soils are suitable for seeding to adapted grasses and forbs if the range is in poor condition. Seedbed preparation and planting on the contour or across the slope, where practical, conserve moisture and help to control water erosion. The surface layer is susceptible to water erosion and soil blowing if it is disturbed or if the range is overgrazed.

The Timberg soil is suited to windbreaks, but the low to moderate available water capacity limits the growth of both trees and shrubs. Suitable trees for planting are Russian-olive, Siberian elm, ponderosa pine, and Rocky Mountain juniper. Suitable shrubs are Siberian peashrub, western sandcherry, and skunkbush sumac. Summer fallow, cultivation for weed control, and adapted plants are needed to insure establishment and survival of seedlings. Planting on the contour conserves moisture.

The Castner soil is poorly suited to windbreaks. It is limited mainly by the very low available water capacity.

The main limitations for homesite development on the Timberg soil are slow permeability, moderate depth to shale, shrink-swell potential, and low soil strength. The soil is severely limited for septic tank absorption fields because of the slow permeability and moderate depth to shale. Cuts to level building sites can expose shale. Shrinking and swelling and low soil strength can damage roadbeds and road surfaces. Adequate drainage and the use of suitable fill material that is properly compacted can overcome these limitations. In the construction of basements or foundations for dwellings, the shrink-swell potential can be overcome by backfilling excavations with suitable material that has low shrink-swell potential.

The main limitations for homesite development on the Castner soil are shallow depth to sandstone, potential frost action, and content of rock fragments. The soil is severely limited for septic tank absorption fields because of the shallow depth to sandstone. Cuts to level building sites can expose sandstone. Frost action can damage roadbeds and road surfaces. Adequate drainage and the use of suitable fill material that is properly compacted can overcome this limitation. Removal of pebbles and cobbles in disturbed areas is needed for best results when landscaping, particularly in areas used for lawns.

This map unit is in capability subclass VIe, nonirrigated. The Timberg soil is in Clayey range site, 15- to 19-inch precipitation zone, and the Castner soil is in Shallow range site, 15- to 19-inch precipitation zone.

242—Timberg-Castner complex, 15 to 45 percent slopes. This map unit is on uplands in the southern part of the county. Slopes commonly are 250 to 1,000 feet long. Elevation is 3,900 to 4,800 feet. The average annual precipitation is about 16 inches, the average annual air temperature is about 43 degrees F, and the average frost-free period is about 120 days.

This unit is about 50 percent Timberg clay loam and 25 percent Castner stony loam. The Timberg soil is on plane side slopes, and the Castner soil is on ridges.

Included in this unit are small areas of deep Bitton, Fergus, and Twin Creek soils on foot slopes and fans; Timberg silty clay; and Rock outcrop in the form of ledges. Included areas make up about 25 percent of the total acreage.

The Timberg soil is moderately deep and well drained. It formed in residuum derived dominantly from semiconsolidated shale interbedded with sandstone. Typically, the surface layer is reddish brown clay loam about 6 inches thick. The subsoil is reddish brown and brown silty clay about 19 inches thick. The substratum is

2 035 000 FEET
(Joins sheet 188)
Breed Creek
Boyd Creek
(Joins sheet 196)
(Joins sheet 198)
T. 15 N.
425 000 FEET
(Joins sheet 206)
12 060 000 FEET
7
11
12
13
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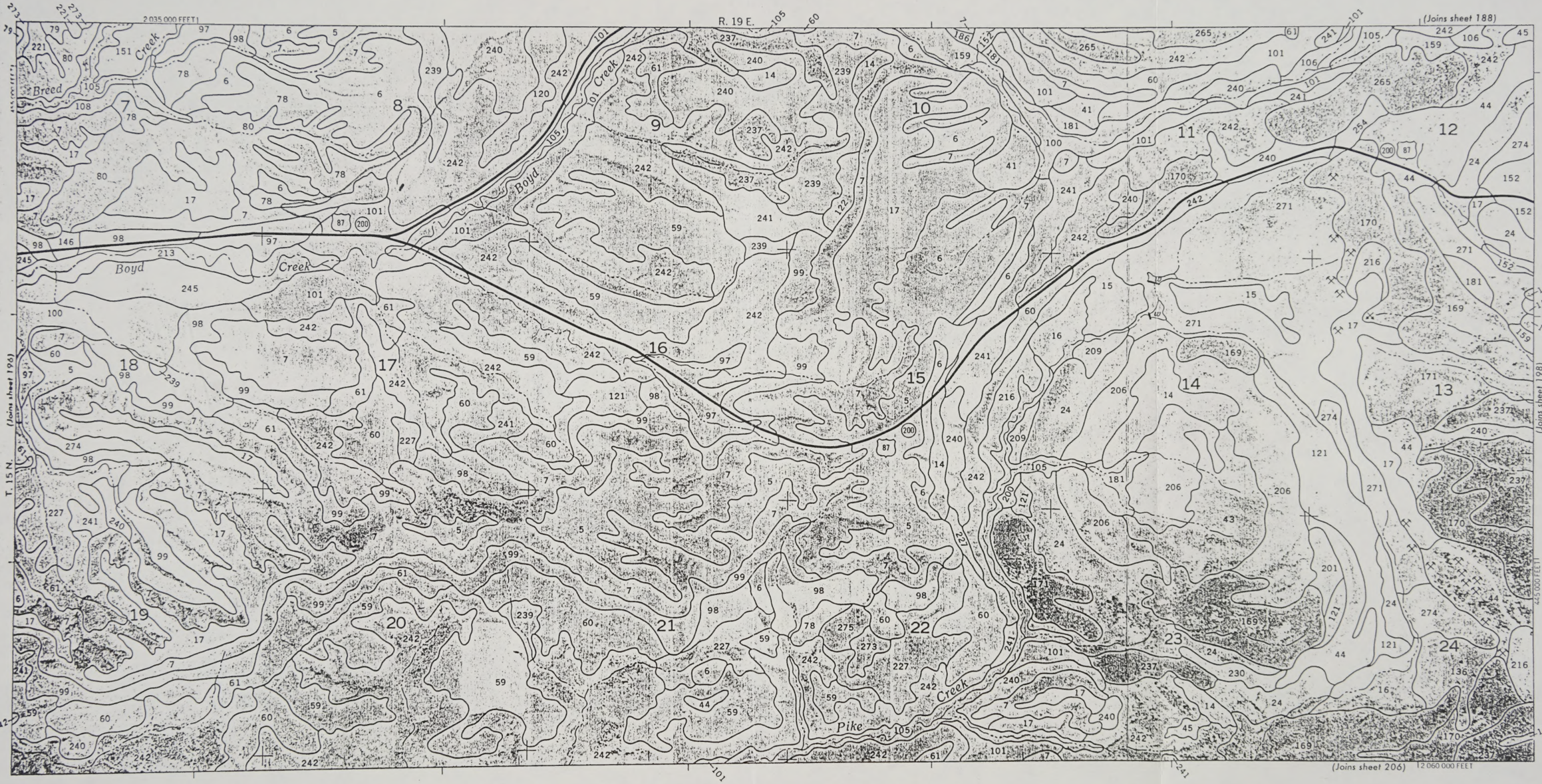
19
23
24
200
87



1 3/4 1/2 1/4 0 1 2 MILES

1 0.5 0 1 2 KILOMETERS

SCALE 1:24000

S. DEPARTMENT OF AGRICULTURE
IL CONSERVATION SERVICE
REST SERVICE

F THE INTERIOR BUREAU OF LAND MANAGEMENT
MONTANA AGRICULTURAL EXPERIMENT STATION

SYMBOL	NAME
1	Abor-Crago complex, 4 to 8 percent slopes
2	Abor-Crago complex, 8 to 25 percent slopes
3	Abor-Thebo-Crago complex, 15 to 45 percent s
4	Abor-Yawdim silty clay loams, 4 to 15 percent
5	Absarokee clay loam, 2 to 8 percent slopes
6	Absarokee-Amherst clay loams, 8 to 15 percen
7	Absarokee-Bitton-Maginnis complex, 15 to 60
8	Absher clay loam, 0 to 4 percent slopes
9	Absher-Nobe complex, 0 to 4 percent slopes
10	Adel loam, 2 to 15 percent slopes
11	Adel-Cheadle complex, 15 to 45 percent slo
12	Adger-Nobe clays, 0 to 2 percent slopes
13	Adger-Nobe clays, 2 to 8 percent slopes
14	Alder clay loam, 2 to 8 percent slopes
15	Alder clay loam, 8 to 15 percent slopes
16	Alder-Winifred clay loams, 15 to 45 percent slo
17	Amherst-Absarokee clay loams, 2 to 8 percent
18	Amherst-Absarokee clay loams, 8 to 25 percen
19	Amor loam, 2 to 8 percent slopes
20	Amor-Cabba loams, 4 to 8 percent slopes
21	Amor-Winifred complex, 8 to 15 percent slope
22	Ashuelot Variant-Crago complex, 0 to 4 percen
23	Bitton very stony loam, 15 to 45 percent slope
24	Bitton-Winifred-Castner complex, 15 to 60 per
25	Borky-Sinnigam channery clay loams, 2 to 8 pe
26	Borky-Sinnigam very stony loams, 2 to 15 perc
27	Brazon-Loken complex, 2 to 15 percent slopes
28	Brazon-Loken complex, 15 to 45 percent slope
29	Bridger clay loam, 2 to 8 percent slopes
30	Bridger-Raynesford complex, 0 to 4 percent slo
31	Bridger Variant clay loam, 15 to 60 percent slo
32	Burnel silty clay loam, 0 to 2 percent slopes
33	Burnel silty clay loam, 2 to 8 percent slopes
34	Burnette silty clay loam, 2 to 8 percent slopes
35	Burnette-Burnette Variant silty clay loams, 2 t
36	Burnette-Burnette Variant silty clay loams, 8 t
37	Cabba-Doney-Wayden complex, 4 to 8 percent
38	Cabba-Wayden-Rock outcrop complex, 45 to 6
39	Cabston-Delplain channery clay loams, 25 to 6
40	Cabston-Delplain-Crago complex, 15 to 45 per
41	Castle clay, 2 to 8 percent slopes
42	Castle clay, 8 to 15 percent slopes
43	Castle clay, 15 to 35 percent slopes
44	Castner complex, 4 to 25 percent slopes
45	Castner-Amherst loams, 2 to 8 percent slopes
46	Cheadle stony loam, 4 to 25 percent slopes
47	Cheadle stony loam, 25 to 60 percent slopes
48	Chinook fine sandy loam, 2 to 15 percent slop
49	Chinook fine sandy loam, 15 to 35 percent slo
50	Crago Variant clay loam, 0 to 4 percent slopes
51	Creed-Gerdrum complex, 0 to 2 percent slopes
52	Creed-Gerdrum complex, 2 to 8 percent slopes
53	Daglum-Adger complex, 0 to 2 percent slopes
54	Daglum-Adger complex, 2 to 8 percent slopes
55	Danvers clay loam, 0 to 2 percent slopes
56	Danvers clay loam, 2 to 8 percent slopes
57	Danvers-Acel clay loams, 0 to 2 percent slopes
58	Danvers-Tamaneen clay loams, 0 to 2 percent
59	Darret loam, 2 to 8 percent slopes
60	Darret clay loam, 2 to 8 percent slopes
61	Darret-Terrad complex, 8 to 15 percent slopes
62	Delpoint-Yawdim complex, 4 to 8 percent slo
63	Dilts-Julin clays, 4 to 15 percent slopes
64	Dilts-Julin Rock outcrop complex, 15 to 50 p
65	Dilts-Thebo-Neldore clays, 4 to 60 percent slo
66	Dilts-Welter-Julin complex, 4 to 25 percent slo
67	Doney-Wayden complex, 15 to 60 percent slo
68	Doney-Windham complex, 8 to 15 percent slo
69	Doney-Windham complex, 15 to 45 percen
70	Doney-Winifred-Wayden complex, 15 to 45 pe
71	Doughty-Ashuelot Variant complex, 0 to 4 pe
72	Doughty-Judith loams, 0 to 2 percent slopes
73	Doughty-Judith loams, 2 to 8 percent slopes
74	Doughty-Judith cobbly loams, 2 to 4 percent
75	Doughty-Sipple loams, 0 to 2 percent slopes
76	Dryadin flaggy silt loam, 2 to 25 percent slope
77	Dumps, mine
78	Eltsac clay, 4 to 8 percent slopes
79	Eltsac-Lawther clays, 2 to 8 percent slopes
80	Eltsac-Norbert clays, 8 to 25 percent slopes
81	Elve-Arcette complex, 15 to 60 percent slopes
82	Enbar loam, 0 to 2 percent slopes
83	Enbar-Nesda loams, 0 to 2 percent slopes
84	Ernem clay loam, 2 to 8 percent slopes
85	Ernem very stony loam, 2 to 8 percent slopes
86	Ernem-Delplain-Tanna complex, 4 to 25 perc
87	Ethridge silty clay loam, 0 to 2 percent slopes
88	Ethridge silty clay loam, 2 to 8 percent slopes
89	Ethridge-Cabston complex, 2 to 8 percent slo
90	Evanston loam, 0 to 2 percent slopes
91	Evanston loam, 2 to 8 percent slopes
92	Fairfield clay loam, 0 to 2 percent slopes
93	Fairfield-Danvers clay loams, 0 to 2 percent
94	Fairfield-Danvers clay loams, 2 to 4 percent s

SOIL LEGEND

SYMBOL	NAME
1	Abor-Crago complex, 4 to 8 percent slopes
2	Abor-Crago complex, 8 to 25 percent slopes
3	Abor-Thebo-Crago complex, 15 to 45 percent slopes
4	Abor-Yawdim silty clay loams, 4 to 15 percent slopes
5	Absarokee clay loam, 2 to 8 percent slopes
6	Absarokee-Amherst clay loams, 8 to 15 percent slopes
7	Absarokee-Bitton-Maginnis complex, 15 to 60 percent slopes
8	Absher clay loam, 0 to 4 percent slopes
9	Absher-Nobe complex, 0 to 4 percent slopes
10	Adel loam, 2 to 15 percent slopes
11	Adel-Cheadle complex, 15 to 45 percent slopes
12	Adger-Nobe clays, 0 to 2 percent slopes
13	Adger-Nobe clays, 2 to 8 percent slopes
14	Alder clay loam, 2 to 8 percent slopes
15	Alder clay loam, 8 to 15 percent slopes
16	Alder-Winifred clay loams, 15 to 45 percent slopes
17	Amherst-Absarokee clay loams, 2 to 8 percent slopes
18	Amherst-Absarokee clay loams, 8 to 25 percent slopes
19	Amor loam, 2 to 8 percent slopes
20	Amor-Cabba loams, 4 to 8 percent slopes
21	Amor-Winifred complex, 8 to 15 percent slopes
22	Ashuelot Variant-Crago complex, 0 to 4 percent slopes
23	Bitton very stony loam, 15 to 45 percent slopes
24	Bitton-Winifred-Castner complex, 15 to 60 percent slopes
25	Borky-Sinnigam channery clay loams, 2 to 8 percent slopes
26	Borky-Sinnigam very stony loams, 2 to 15 percent slopes
27	Brazon-Loken complex, 2 to 15 percent slopes
28	Brazon-Loken complex, 15 to 45 percent slopes
29	Bridger clay loam, 2 to 8 percent slopes
30	Bridger-Raynesford complex, 0 to 4 percent slopes
31	Bridger Variant clay loam, 15 to 60 percent slopes
32	Burnel silty clay loam, 0 to 2 percent slopes
33	Burnel silty clay loam, 2 to 8 percent slopes
34	Burnette silty clay loam, 2 to 8 percent slopes
35	Burnette-Burnette Variant silty clay loams, 2 to 8 percent slopes
36	Burnette-Burnette Variant silty clay loams, 8 to 15 percent slopes
37	Cabba-Doney-Wayden complex, 4 to 8 percent slopes
38	Cabba-Wayden-Rock outcrop complex, 45 to 60 percent slopes
39	Cabston-Delplain channery clay loams, 25 to 60 percent slopes
40	Cabston-Delplain-Crago complex, 15 to 45 percent slopes
41	Castle clay, 2 to 8 percent slopes
42	Castle clay, 8 to 15 percent slopes
43	Castle clay, 15 to 35 percent slopes
44	Castner complex, 4 to 25 percent slopes
45	Castner-Amherst loams, 2 to 8 percent slopes
46	Cheadle stony loam, 4 to 25 percent slopes
47	Cheadle stony loam, 25 to 60 percent slopes
48	Chinook fine sandy loam, 2 to 15 percent slopes
49	Chinook fine sandy loam, 15 to 35 percent slopes
50	Crago Variant clay loam, 0 to 4 percent slopes
51	Creed-Gerdrum complex, 0 to 2 percent slopes
52	Creed-Gerdrum complex, 2 to 8 percent slopes
53	Daglum-Adger complex, 0 to 2 percent slopes
54	Daglum-Adger complex, 2 to 8 percent slopes
55	Danvers clay loam, 0 to 2 percent slopes
56	Danvers clay loam, 2 to 8 percent slopes
57	Danvers-Acel clay loams, 0 to 2 percent slopes
58	Danvers-Tamaneen clay loams, 0 to 2 percent slopes
59	Darret loam, 2 to 8 percent slopes
60	Darret clay loam, 2 to 8 percent slopes
61	Darret-Terrad complex, 8 to 15 percent slopes
62	Delpoint-Yawdim complex, 4 to 8 percent slopes
63	Dilts-Julin clays, 4 to 15 percent slopes
64	Dilts-Julin Rock outcrop complex, 15 to 50 percent slopes
65	Dilts-Thebo-Neldore clays, 4 to 60 percent slopes
66	Dilts-Welter-Julin complex, 4 to 25 percent slopes
67	Doney-Wayden complex, 15 to 60 percent slopes
68	Doney-Windham complex, 8 to 15 percent slopes
69	Doney-Windham complex, 15 to 45 percent slopes
70	Doney-Winifred-Wayden complex, 15 to 45 percent slopes
71	Doughty-Ashuelot Variant complex, 0 to 4 percent slopes
72	Doughty-Judith loams, 0 to 2 percent slopes
73	Doughty-Judith loams, 2 to 8 percent slopes
74	Doughty-Judith cobbly loams, 2 to 4 percent slopes
75	Doughty-Sipple loams, 0 to 2 percent slopes
76	Dryadin flaggy silt loam, 2 to 25 percent slopes
77	Dumps, mine
78	Eltsac clay, 4 to 8 percent slopes
79	Eltsac-Lawther clays, 2 to 8 percent slopes
80	Eltsac-Norbert clays, 8 to 25 percent slopes
81	Elve-Arcette complex, 15 to 60 percent slopes
82	Enbar loam, 0 to 2 percent slopes
83	Enbar-Nesda loams, 0 to 2 percent slopes
84	Ernem clay loam, 2 to 8 percent slopes
85	Ernem very stony loam, 2 to 8 percent slopes
86	Ernem-Delplain-Tanna complex, 4 to 25 percent slopes
87	Ethridge silty clay loam, 0 to 2 percent slopes
88	Ethridge silty clay loam, 2 to 8 percent slopes
89	Ethridge-Cabston complex, 2 to 8 percent slopes
90	Evanston loam, 0 to 2 percent slopes
91	Evanston loam, 2 to 8 percent slopes
92	Fairfield clay loam, 0 to 2 percent slopes
93	Fairfield-Danvers clay loams, 0 to 2 percent slopes
94	Fairfield-Danvers clay loams, 2 to 4 percent slopes
95	Fairfield-Judell clay loams, 0 to 2 percent slopes
96	Fairfield-Judell clay loams, 2 to 8 percent slopes
97	Farnuf loam, 0 to 4 percent slopes
98	Farnuf loam, 4 to 8 percent slopes
99	Farnuf loam, 8 to 15 percent slopes
100	Fergus clay loam, 0 to 2 percent slopes
101	Fergus clay loam, 2 to 8 percent slopes
102	Firada-Sheege-Rock outcrop complex, 25 to 60 percent slopes
103	Flasher-Tally-Rock outcrop complex, 25 to 45 percent slopes
104	Floweree silt loam, 2 to 8 percent slopes
105	Fluvaquentic Haplaquolls, nearly level
106	Frazer silty clay loam
107	Gerber clay loam, 0 to 2 percent slopes
108	Gerber clay loam, 2 to 4 percent slopes
109	Gerber silty clay, 0 to 4 percent slopes
110	Gerber-Winifred clay loams, 2 to 8 percent slopes
111	Gerdrum clay loam, 0 to 4 percent slopes
112	Gerdrum-Absher complex, 0 to 2 percent slopes
113	Gerdrum-Absher complex, 2 to 8 percent slopes
114	Hanson very stony loam, 2 to 15 percent slopes
115	Harlem silty clay loam
116	Havre loam
117	Havre silty clay loam
118	Havre and Harlem soils, occasionally flooded
119	Hibar loam, 2 to 8 percent slopes
120	Hibar-Castner loams, 2 to 8 percent slopes
121	Hibar-Castner loams, 8 to 15 percent slopes
122	Hibar-Castner channery loams, 2 to 8 percent slopes
123	Hoosan silty clay loam, 2 to 8 percent slopes
124	Hughesville-Skaggs flaggy loams, 15 to 60 percent slopes
125	Hughesville-Tibs-Whitecow complex, 2 to 25 percent slopes
126	Judith loam, 0 to 2 percent slopes
127	Judith gravelly loam, 2 to 4 percent slopes
128	Judith-Judell clay loams, 0 to 2 percent slopes
129	Judith-Judell clay loam,s 2 to 4 percent slopes
130	Judith-Tamaneed clay loams, 0 to 2 percent slopes
131	Judith-Windham clay loams, 0 to 2 percent slopes
132	Judith-Windham gravelly clay loams, 0 to 2 percent slopes
133	Judith-Windham gravelly clay loams, 2 to 8 percent slopes
134	Judith-Windham gravelly clay loams, 8 to 15 percent slopes
135	Julin-Dilts clays, 2 to 25 percent slopes
136	Kildor clay loam, 2 to 15 percent slopes
137	Kildor-Sheege complex, 25 to 60 percent slopes
138	Kildor-Skaggs-Hanson complex, 15 to 45 percent slopes
139	Klayent clay loam, 0 to 2 percent slopes
140	Kobar silty clay loam, 0 to 2 percent slopes
141	Kobar silty clay loam, 2 to 8 percent slopes
142	Kobar silty clay loam, gullied, 2 to 25 percent slopes
143	Korchea loam
144	Korchea and Frazier soils, occasionally flooded
145	Lawther silty clay, 0 to 2 percent slopes
146	Lawther silty clay, 2 to 4 percent slopes
147	Libeg flaggy loam, 15 to 45 percent slopes
148	Libeg-Cheadle complex, 25 to 70 percent slopes
149	Linnet clay loam, 0 to 2 percent slopes
150	Linnet clay loam, 2 to 8 percent slopes
151	Linwell silty clay loam, 0 to 2 percent slopes
152	Linwell silty clay loam, 2 to 8 percent slopes
153	Linwell-Winifred clay loams, 4 to 8 percent slopes
154	Little Horn silt loam, 2 to 8 percent slopes
155	Little Horn silt loam, 8 to 15 percent slopes
156	Little Horn-Skaggs stony loams, 4 to 15 percent slopes
157	Loken-Brazon silty clay loams, 2 to 8 percent slopes
158	Lolo very gravelly loam, 0 to 4 percent slopes
159	Marcott silty clay loam
160	Marias silty clay, 0 to 2 percent slopes
161	Marias silty clay, 2 to 8 percent slopes
162	Marmarth loam, 2 to 8 percent slopes
163	Marmarth-Cabbart loams, 4 to 8 percent slopes
164	Martinsdale loam, 0 to 4 percent slopes
165	Martinsdale-Judith loams, 4 to 8 percent slopes
166	Marvan silty clay, 0 to 2 percent slopes
167	Marvan silty clay, 2 to 8 percent slopes
168	Mocmont very gravelly loam, 15 to 60 percent slopes
169	Mocmont-Lipke association, steep
170	Mocmont-Oraid complex, 2 to 25 percent slopes
171	Mocmont-Oraid complex, 25 to 60 percent slopes
172	Mocmont-Oraid complex, warm, 4 to 60 percent slopes
173	Mocmont-Roy flaggy loams, 15 to 45 percent slopes
174	Neldore-Thebo clays, 4 to 25 percent slopes
175	Neldore-Thebo clays, 25 to 60 percent slopes
176	Neldore-Rock outcrop complex, 15 to 60 percent slopes
177	Nesda Variant complex
178	Nesda-Sudworth complex, occasionally flooded
179	Norbert-Eltsac clays, 15 to 60 percent slopes
180	Pekay silty clay, 0 to 2 percent slopes
181	Pekay silty clay, 2 to 8 percent slopes
182	Pendroy clay, 0 to 4 percent slopes
183	Pits, gravel
184	Raynesford-Hanson complex, 0 to 4 percent slopes
185	Raynesford-Hanson complex, 4 to 15 percent slopes
186	Reeder loam, 2 to 8 percent slopes
187	Regent silty clay loam, 2 to 8 percent slopes
188	Regent silty clay, 2 to 8 percent slopes
189	Richey silty clay loam, 0 to 2 percent slopes
190	Rock outcrop
191	Rock outcrop-Rubble land association
192	Roy gravelly clay loam, 0 to 2 percent slopes
193	Roy gravelly clay loam, 2 to 8 percent slopes
194	Roy very stony clay loam, 2 to 8 percent slopes
195	Roy-Winifred complex, 8 to 45 percent slopes
196	Sanje clay loam, 0 to 4 percent slopes
197	Savage silty clay loam, 0 to 2 percent slopes
198	Savage silty clay loam, 2 to 8 percent slopes
199	Shambo loam, 0 to 2 percent slopes,
200	Shambo loam, 2 to 8 percent slopes
201	Shambo-Labre complex, 2 to 8 percent slopes
202	Shambo-Labre complex, 8 to 15 percent slopes
203	Sheege-Rock outcrop complex, 15 to 60 percent slopes
204	Sheege-Skaggs very stony loams, 2 to 15 percent slopes
205	Sipple loam, 0 to 4 percent slopes
206	Skaggs-Sheege very stony loams, 15 to 60 percent slopes
207	Skaggs-Sheege complex, 2 to 15 percent slopes
208	Straw loam, 0 to 2 percent slopes
209	Straw loam, 2 to 8 percent slopes
210	Straw clay loam, 0 to 2 percent slopes
211	Straw-Korchea loams, 0 to 2 percent slopes
212	Sudworth loam
213	Sudworth-Nesda loams
214	Syblon loam, 2 to 8 percent slopes
215	Tally fine sandy loam, 2 to 8 percent slopes
216	Tally-Flasher complex, 4 to 25 percent slopes
217	Tally-Flasher complex, 25 to 45 percent slopes
218	Tamaneen clay loam, 0 to 2 percent slopes
219	Tamaneen clay loam, 2 to 4 percent slopes
220	Tamaneen-Judith clay loams, 0 to 2 percent slopes
221	Tamaneen-Judith clay loams, 2 to 4 percent slopes
222	Tanna silty clay loam, 0 to 4 percent slopes
223	Tanna-Abor complex, 2 to 8 percent slopes
224	Tanna-Ethridge-Cabston complex, 8 to 25 percent slopes
225	Teigen silty clay loam, 2 to 8 percent slopes
226	Teigen-Julin complex, 2 to 25 percent slopes
227	Terrad silty clay, 2 to 8 percent slopes
228	Teton loam, 2 to 8 percent slopes
229	Teton-Adel loams, 8 to 15 percent slopes
230	Teton-Cheadle loams, 2 to 8 percent slopes
231	Teton-Cheadle loams, 8 to 15 percent slopes
232	Teton-Cheadle channery loams, 2 to 8 percent slopes
233	Thebo clay, 2 to 8 percent slopes
234	Thebo clay, 8 to 25 percent slopes
235	Thebo-Weingart-Absher clays, 4 to 15 percent slopes
236	Tibs-Whitecow cobbly clay loams, 25 to 60 percent slopes
237	Tibs-Widen-Mocmont complex, 15 to 45 percent slopes
238	Tigeron very gravelly loam, 15 to 60 percent slopes
239	Timberg clay, 2 to 8 percent slopes
240	Timberg-Castner complex, 2 to 8 percent slopes
241	Timberg-Castner complex, 8 to 15 percent slopes
242	Timberg-Castner complex, 15 to 45 percent slopes
243	Tomty complex, 4 to 25 percent slopes
244	Tomty-Delette complex, 8 to 25 percent slopes
245	Turner loam, 0 to 2 percent slopes
246	Twin Creek loam, 2 to 8 percent slopes
247	Typic Albaqualfs, level
248	Typic Cryaquolls, nearly level
249	Typic Haplaquepts and Typic Haplaquolls, saline
250	Typic Haplaquolls, moderately sloping
251	Typic Ustifluvents, saline
252	Vanda clay, 0 to 8 percent slopes
253	Vanda-Nobe clays, 0 to 4 percent slopes
254	Vebar fine sandy loam, 4 to 15 percent slopes
255	Verson clay loam, 0 to 4 percent slopes
256	Verson-Linnet clay loams, 2 to 8 percent slopes
257	Weingart very stony clay loam, 2 to 8 percent slopes
258	Weingart-Gerdrum clay loams, 0 to 4 percent slopes
259	Weingart-Gerdrum clay loams, 4 to 15 percent slopes
260	Weingart-Absher clays, 0 to 4 percent slopes
261	Whitecow-Hughesville complex, 2 to 20 percent slopes
262	Whitecow-Hughesville complex, 20 to 60 percent slopes
263	Whitecow-Hughesville-Rock outcrop complex, 45 to 60 percent slopes
264	Whitore-Firada cobbly clay loams, 15 to 60 percent slopes
265	Widen-Hughesville-Lipke complex, 15 to 60 percent slopes
266	Windham gravelly loam, 0 to 4 percent slopes
267	Windham very gravelly loam, 2 to 8 percent slopes
268	Windham very gravelly loam, 8 to 45 percent slopes
269	Windham very stony loam, 2 to 15 percent slopes
270	Winifred clay loam, 2 to 8 percent slopes
271	Winifred-Castner-Norbert complex, 8 to 45 percent slopes
272	Winifred-Judith clay loams, 4 to 8 percent slopes
273	Winifred-Judith clay loams, 8 to 15 percent slopes
274	Winifred-Linwell clay loams, 8 to 15 percent slopes
275	Winifred-Windham-Eltsac complex, 15 to 45 percent slopes
276	Work clay loam, 0 to 2 percent slopes
277	Work clay loam, 2 to 8 percent slopes
278	Yamac loam, 2 to 8 percent slopes
279	Yamac-Delpoint-Yawdim complex, 4 to 25 percent slopes
280	Yamac Variant loam
281	Yawdim-Abor-Rentsac complex, 8 to 60 percent slopes
282	Yawdim-Delpoint-Rock outcrop complex, 25 to 50 percent slopes

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of	sion
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
235*:												
Thebo	D	None	---	---	>6.0	---	---	20-40	Soft	Low	High	Moderate.
Weingart	D	None	---	---	>6.0	---	---	20-40	Soft	Low	High	Moderate.
Absher	D	None	---	---	>6.0	---	---	>60	---	Low	High	Moderate.
236*:												
Tibs	C	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Low.
Whitecow	B	None	---	---	>6.0	---	---	>60	---	Moderate	High	Low.
237*:												
Tibs	C	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Low.
Widen	C	None	---	---	>6.0	---	---	20-40	Soft	Moderate	High	Low.
Mocmont	B	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Moderate.
238 Tigeron	B	None	---	---	>6.0	---	---	>60	---	Moderate	High	Moderate.
239 Timberg	C	None	---	---	>6.0	---	---	20-40	Soft	Low	High	Low.
240*, 241*, 242*:												
Timberg	C	None	---	---	>6.0	---	---	20-40	Soft	Low	High	Low.
Castner	D	None	---	---	>6.0	---	---	10-20	Hard	Moderate	High	Low.
243*:												
Tomty	D	None	---	---	1.5-3.0	Apparent	Apr-Jul	>60	---	Moderate	Moderate	Low.
Tomty	D	None	---	---	1.5-3.0	Apparent	Apr-Jul	>60	---	Moderate	Moderate	Low.
244*:												
Tomty	D	None	---	---	1.5-3.0	Apparent	Apr-Jul	>60	---	Moderate	Moderate	Low.
Delette	C	None	---	---	3.5-5.0	Apparent	Apr-Jul	>60	---	High	Moderate	Moderate.
245 Turner	B	None	---	---	>6.0	---	---	>60	---	Moderate	High	Low.
246 Twin Creek	B	None	---	---	>6.0	---	---	>60	---	Moderate	High	Low.
247*. Typic Albaqualfs												

See footnote at end of table.

APPENDIX B

NOAA ATLAS

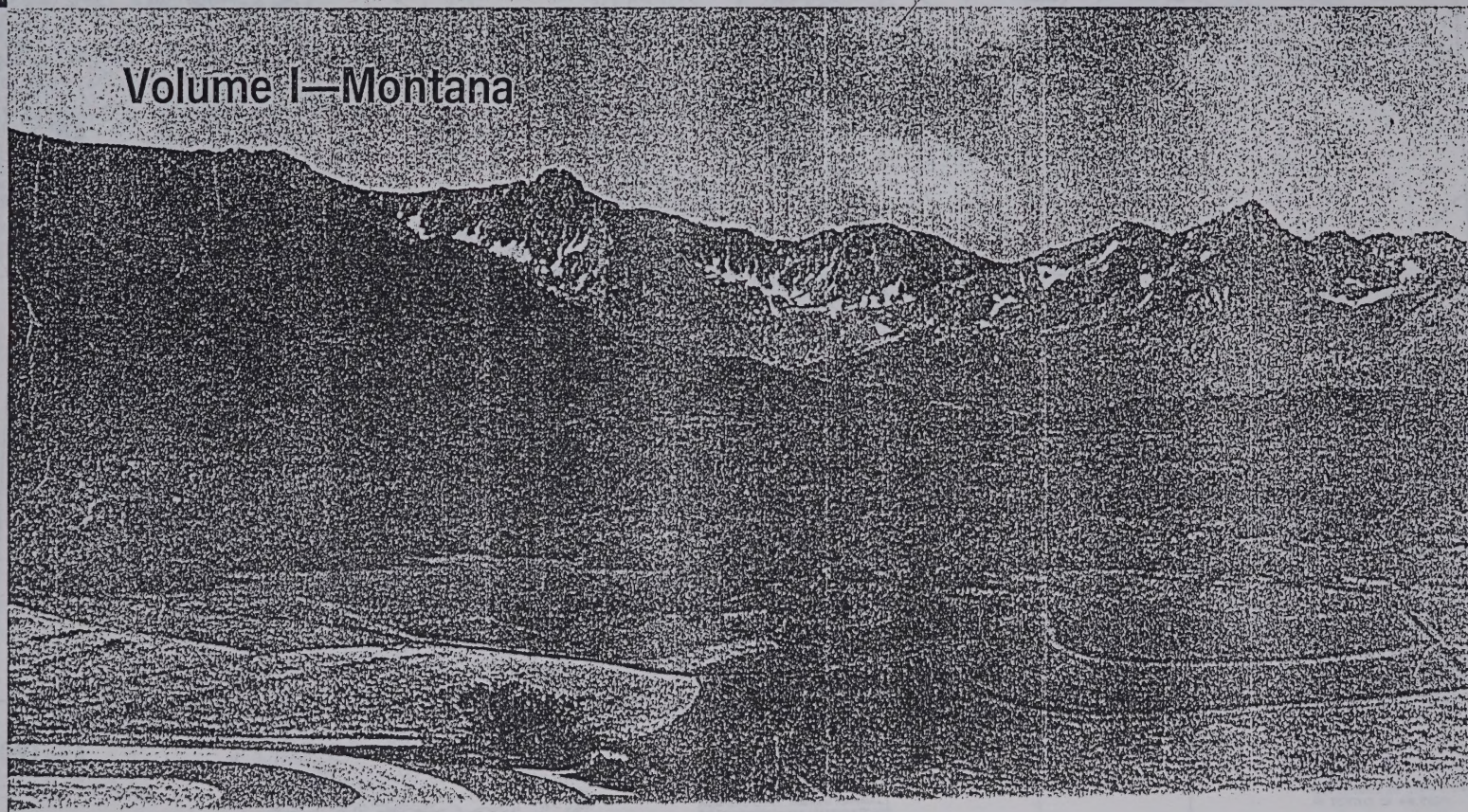
NOAA ATLAS 2

UNITED STATES
EPARTMENT OF
COMMERCE
UBLICATION

Precipitation-Frequency Atlas of the Western U

J. F. Miller, R. H. Frederick, and R. J. Tracey

Volume I—Montana



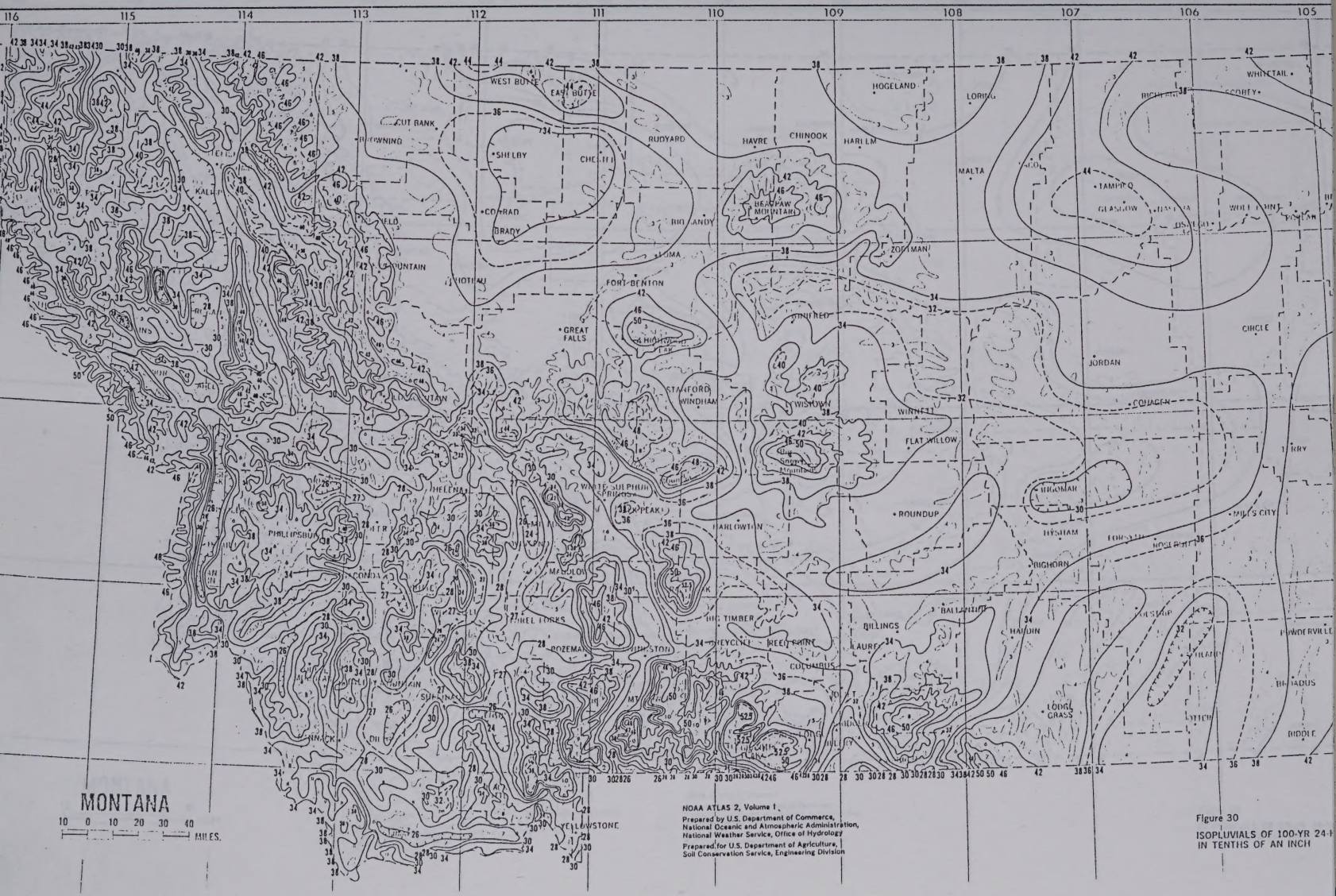


Figure 30

ISOPLUVIALS OF 100-YR 24-H
IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume I

Prepared by U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture, Soil Conservation Service, Engineering Division

Figure 29

ISOPLUVIALS OF 50-YR 24-H
IN TENTHS OF AN INCH

Figure 28

ISOPLUVIALS OF 25-YR 24-HR PR
IN TENTHS OF AN INCH

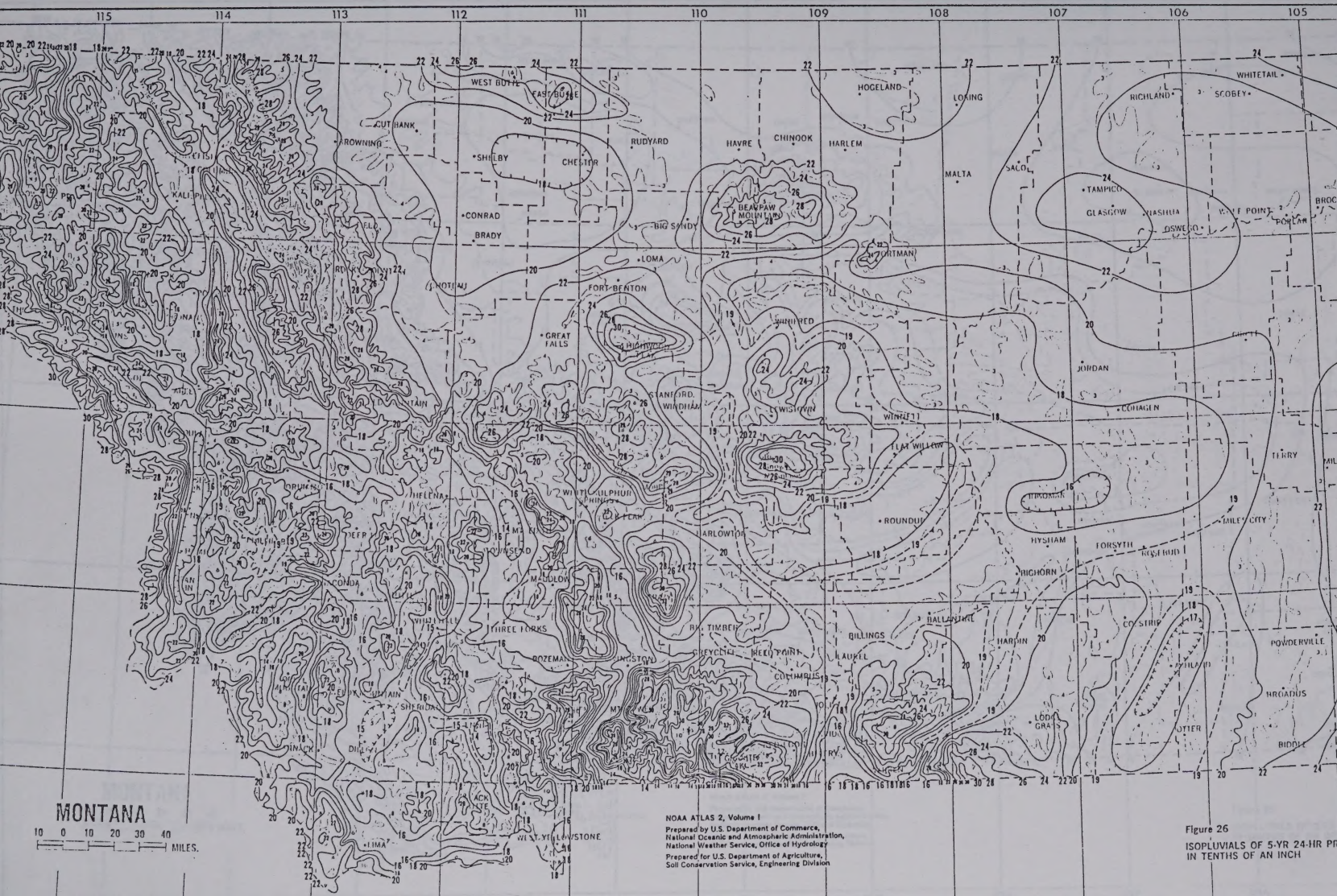
NOAA ATLAS 2, Volume I

Prepared by U.S. Department of Commerce,
National Oceanic and Atmospheric Administration,
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

Figure 27

ISOPLUVIALS OF 10-YR 24-
IN TENTHS OF AN INCH



NOAA ATLAS 2, Volume I

Prepared by U.S. Department of Commerce,
National Oceanic and Atmospheric Administration,
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

Figure 26

ISOPLUVIALS OF 5-YR 24-HR PR
IN TENTHS OF AN INCH

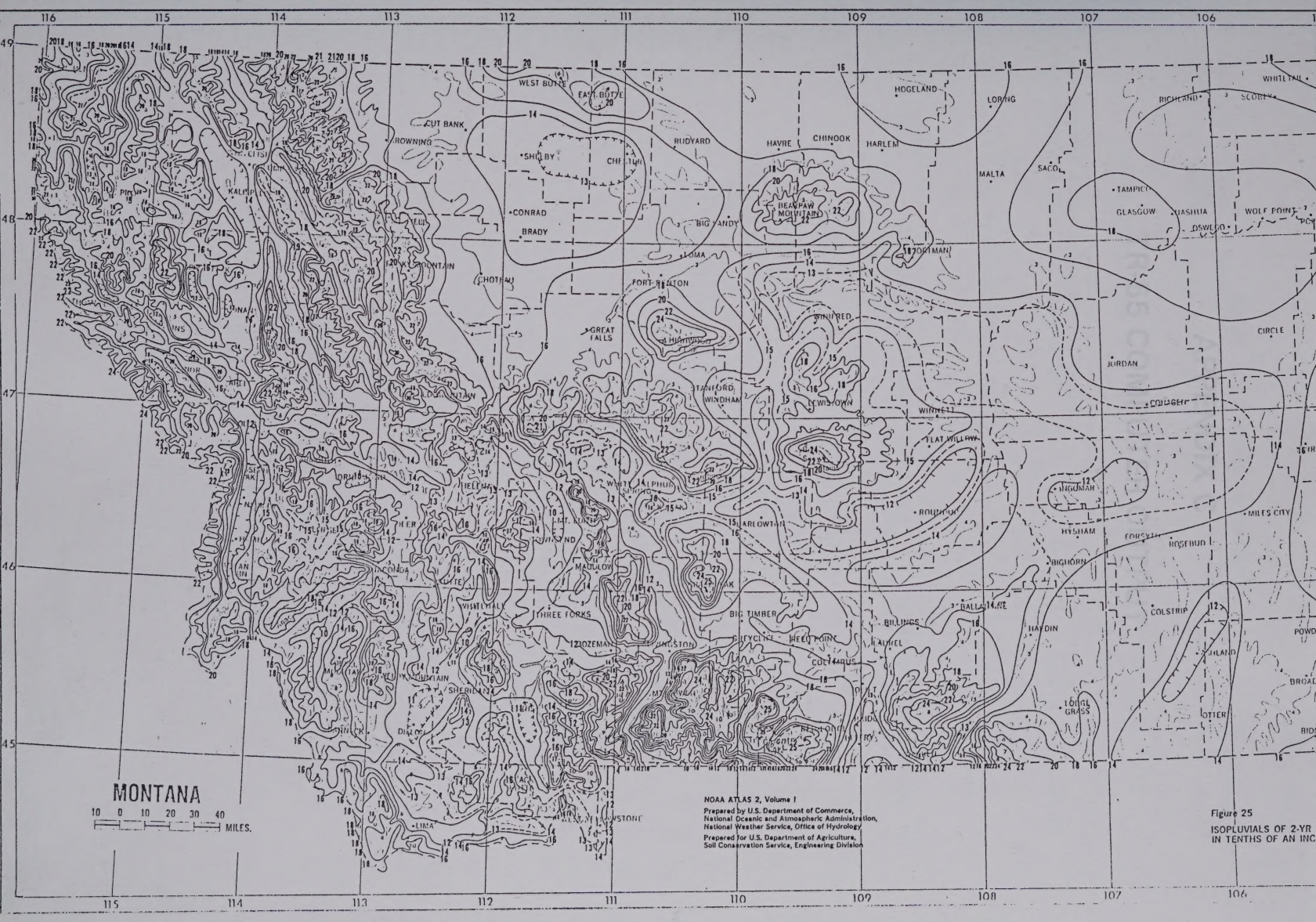


Figure 25

ISOPLUVIALS OF 2-YR
IN TENTHS OF AN INC

APPENDIX C

TR-55 COMPUTER OUTPUT

25-year

RUNOFF CURVE NUMBER COMPUTATION

Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 1

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
DEVELOPING URBAN AREA (No Vegetation)				
Newly graded area (pervious only)	-	-	-	3.9(94)
Total Area (by Hydrologic Soil Group)				3.9
				====

SUBAREA: 1 TOTAL DRAINAGE AREA: 3.9 Acres WEIGHTED CURVE NUMBER: 94

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 2

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
DEVELOPING URBAN AREA (No Vegetation)				
Newly graded area (pervious only)	-	-	-	5.0(94)
Total Area (by Hydrologic Soil Group)				5

SUBAREA: 2 TOTAL DRAINAGE AREA: 5 Acres WEIGHTED CURVE NUMBER: 94

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 3

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
DEVELOPING URBAN AREA (No Vegetation)				
Newly graded area (pervious only)	-	-	-	7.1(94)
Total Area (by Hydrologic Soil Group)				7.1

SUBAREA: 3 TOTAL DRAINAGE AREA: 7.1 Acres WEIGHTED CURVE NUMBER: 94

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 4

COVER DESCRIPTION		Hydrologic Soil Group A	B	C	D
		Acres (CN)			
OTHER AGRICULTURAL LANDS					
Pasture, grassland or range	fair	-	-	-	5.8(84)
Total Area (by Hydrologic Soil Group)					5.8

SUBAREA: 4 TOTAL DRAINAGE AREA: 5.8 Acres WEIGHTED CURVE NUMBER: 84

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 5

COVER DESCRIPTION		Hydrologic Soil Group A	B	C	D
		Acres (CN)			
OTHER AGRICULTURAL LANDS					
Pasture, grassland or range	fair	-	-	-	11.7(84)
Total Area (by Hydrologic Soil Group)					11.7

SUBAREA: 5 TOTAL DRAINAGE AREA: 11.7 Acres WEIGHTED CURVE NUMBER: 84

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan

---------- Subarea #1 - 1 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	944						3.1	0.085

Time of Concentration = 0.08*
=====

---------- Subarea #2 - 2 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1253						3.1	0.112

Time of Concentration = 0.11*
=====

---------- Subarea #3 - 3 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1833						2.6	0.196

Time of Concentration = 0.20*
=====

---------- Subarea #4 - 4 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1956						2.6	0.209

Time of Concentration = 0.21*
=====

---------- Subarea #5 - 5 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1885						2.5	0.209

Time of Concentration = 0.21*
=====

--- Sheet Flow Surface Codes ---

A Smooth Surface
B Fallow (No Res.)
C Cultivated < 20 % Res.
D Cultivated > 20 % Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense
J Range, Natural

--- Shallow Concentrated --- Surface Codes ---

P Paved
U Unpaved

* - Generated for use by TABULAR method

TABULAR HYDROGRAPH METHOD Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan

Total watershed area: 0.052 sq mi Rainfall type: II Frequency: 25 years

	Subareas				
	1	2	3	4	5
Area(sq mi)	0.01*	0.01*	0.01*	0.01*	0.02*
Rainfall(in)	3.0	3.0	3.0	3.0	3.0
Curve number	94*	94*	94*	84*	84*
Runoff(in)	2.35	2.35	2.35	1.52	1.52
Tc (hrs)	0.08*	0.11*	0.20*	0.21*	0.21*
(Used)	0.10	0.10	0.20	0.20	0.20
TimeToOutlet	0.00	0.00	0.00	0.00	0.00
Ia/P	0.04	0.04	0.04	0.13	0.13
(Used)	0.10	0.10	0.10	0.13	0.13

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2	3	4	5
11.0	2	0	0	1	0	1
11.3	3	0	1	1	0	1
11.6	5	1	1	1	1	1
11.9	24	5	6	5	3	5
12.0	47	9	12	11	5	10
12.1	82P	14P	19P	19	10	20
12.2	75	9	12	21P	11P	22P
12.3	40	3	4	13	7	13
12.4	22	2	3	7	3	7
12.5	15	2	2	4	2	5
12.6	12	1	2	3	2	4
12.7	10	1	2	3	1	3
12.8	7	1	1	2	1	2
13.0	7	1	1	2	1	2
13.2	7	1	1	2	1	2
13.4	6	1	1	1	1	2
13.6	5	1	1	1	1	1
13.8	5	1	1	1	1	1
14.0	5	1	1	1	1	1
14.3	4	0	1	1	1	1
14.6	3	0	1	1	0	1
15.0	3	0	1	1	0	1
15.5	2	0	0	1	0	1
16.0	2	0	0	1	0	1
16.5	2	0	0	1	0	1
17.0	2	0	0	1	0	1
17.5	1	0	0	0	0	1
18.0	1	0	0	0	0	1
19.0	0	0	0	0	0	0
20.0	0	0	0	0	0	0
22.0	0	0	0	0	0	0
26.0	0	0	0	0	0	0

P - Peak Flow * - value(s) provided from TR-55 system routines

STORAGE VOLUME FOR DETENTION BASINS Version 2.00

oject : Mister M Landfill User: kws Date: 10-03-94
unty : Fergus State: MT Checked: ____ Date: _____
btitle: Run-off/Run-on Control Plan

Drainage Area: 16 Acres Rainfall Frequency: 25 years
Rainfall-Type: II
Runoff: 1.9 inches
Peak Inflow: 54 cfs
Detention Basin Storage Volume: .55 acre-feet
Peak Outflow: 37 cfs

100-year

RUNOFF CURVE NUMBER COMPUTATION

Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 1

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
DEVELOPING URBAN AREA (No Vegetation)				
Newly graded area (pervious only)	-	-	-	3.9(94)
Total Area (by Hydrologic Soil Group)				3.9
				====

SUBAREA: 1 TOTAL DRAINAGE AREA: 3.9 Acres WEIGHTED CURVE NUMBER: 94

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 2

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
DEVELOPING URBAN AREA (No Vegetation)				
Newly graded area (pervious only)	-	-	-	5.0(94)
Total Area (by Hydrologic Soil Group)				5

SUBAREA: 2 TOTAL DRAINAGE AREA: 5 Acres WEIGHTED CURVE NUMBER: 94

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 3

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
DEVELOPING URBAN AREA (No Vegetation)				
Newly graded area (pervious only)	-	-	-	7.1(94)
Total Area (by Hydrologic Soil Group)				7.1

SUBAREA: 3 TOTAL DRAINAGE AREA: 7.1 Acres WEIGHTED CURVE NUMBER: 94

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 4

COVER DESCRIPTION		Hydrologic Soil Group A	B	C	D
			Acres (CN)		
OTHER AGRICULTURAL LANDS					
Pasture, grassland or range	fair	-	-	-	5.8(84)
Total Area (by Hydrologic Soil Group)					5.8

SUBAREA: 4 TOTAL DRAINAGE AREA: 5.8 Acres WEIGHTED CURVE NUMBER: 84

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan
Subarea : 5

COVER DESCRIPTION		Hydrologic Soil Group A	B	C	D
		Acres (CN)			
OTHER AGRICULTURAL LANDS					
Pasture, grassland or range	fair	-	-	-	11.7(84)
Total Area (by Hydrologic Soil Group)					11.7

SUBAREA: 5 TOTAL DRAINAGE AREA: 11.7 Acres WEIGHTED CURVE NUMBER: 84

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan

---------- Subarea #1 - 1 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	944						3.1	0.085

Time of Concentration = 0.08*
=====

---------- Subarea #2 - 2 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1253						3.1	0.112

Time of Concentration = 0.11*
=====

---------- Subarea #3 - 3 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1833						2.6	0.196

Time of Concentration = 0.20*
=====

---------- Subarea #4 - 4 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1956						2.6	0.209

Time of Concentration = 0.21*
=====

---------- Subarea #5 - 5 ----------

Flow Type	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Open Channel	1885						2.5	0.209

Time of Concentration = 0.21*
=====

--- Sheet Flow Surface Codes ---

A Smooth Surface
B Fallow (No Res.)
C Cultivated < 20 % Res.
D Cultivated > 20 % Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense
J Range, Natural

--- Shallow Concentrated --- Surface Codes ---

P Paved
U Unpaved

* - Generated for use by TABULAR method

TABULAR HYDROGRAPH METHOD Version 2.00

Project : Mister M Landfill User: kws Date: 10-03-94
County : Fergus State: MT Checked: ____ Date: _____
Subtitle: Run-off/Run-on Control Plan

Total watershed area: 0.052 sq mi Rainfall type: II Frequency: 100 years

	Subareas				
	1	2	3	4	5
Area(sq mi)	0.01*	0.01*	0.01*	0.01*	0.02*
Rainfall(in)	3.8	3.8	3.8	3.8	3.8
Curve number	94*	94*	94*	84*	84*
Runoff(in)	3.13	3.13	3.13	2.20	2.20
Tc (hrs)	0.08*	0.11*	0.20*	0.21*	0.21*
(Used)	0.10	0.10	0.20	0.20	0.20
TimeToOutlet	0.00	0.00	0.00	0.00	0.00
Ia/P	0.03	0.03	0.03	0.10	0.10
(Used)	0.10	0.10	0.10	0.10	0.10

Time (hr)	Total Flow	Subarea Contribution to Total Flow (cfs) 1	2	3	4	5
11.0	3	0	1	1	0	1
11.3	5	1	1	1	1	1
11.6	7	1	1	2	1	2
11.9	33	6	8	7	4	8
12.0	66	12	16	14	8	16
12.1	115P	19P	25P	26	15	30
12.2	103	12	15	28P	16P	32P
12.3	55	4	5	17	10	19
12.4	31	3	4	9	5	10
12.5	21	2	3	6	3	7
12.6	17	2	3	4	3	5
12.7	14	2	2	4	2	4
12.8	11	1	2	3	2	3
13.0	9	1	2	2	1	3
13.2	7	1	1	2	1	2
13.4	7	1	1	2	1	2
13.6	7	1	1	2	1	2
13.8	7	1	1	2	1	2
14.0	6	1	1	1	1	2
14.3	5	1	1	1	1	1
14.6	5	1	1	1	1	1
15.0	5	1	1	1	1	1
15.5	4	0	1	1	1	1
16.0	3	0	1	1	0	1
16.5	3	0	1	1	0	1
17.0	2	0	0	1	0	1
17.5	2	0	0	1	0	1
18.0	2	0	0	1	0	1
19.0	2	0	0	1	0	1
20.0	1	0	0	0	0	1
22.0	0	0	0	0	0	0
26.0	0	0	0	0	0	0

P - Peak Flow * - value(s) provided from TR-55 system routines

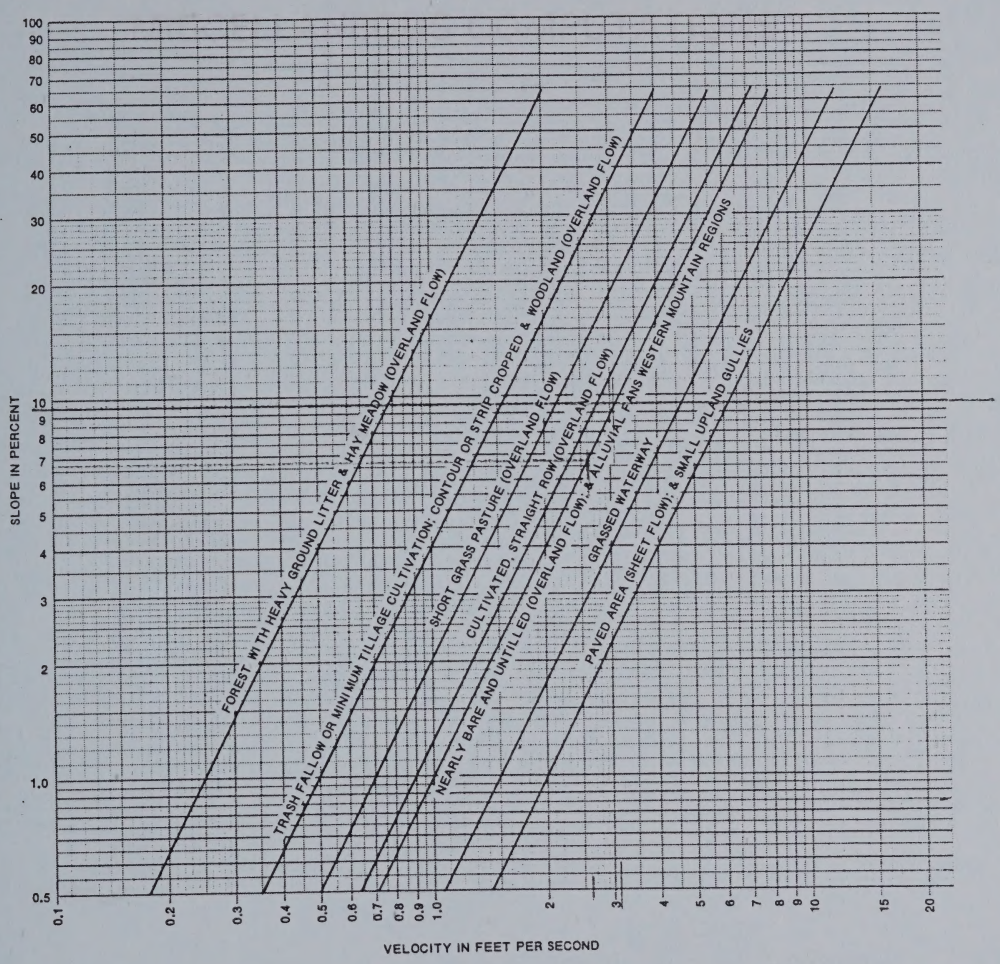


Figure 15.2.--Velocities for upland method of estimating T_c

APPENDIX D

MISCELLANEOUS COMPUTATIONS

Pipe under Pond 2

CURRENT DATE: 01-05-1995
CURRENT TIME: 16:50:49

FILE DATE: 01-05-1995
FILE NAME: MISTERM2

FHWA CULVERT ANALYSIS
HY-8, VERSION 4.3

CULV	SITE DATA			CULVERT SHAPE, MATERIAL, INLET				
	INLET ELEV. (FT)	OUTLET ELEV. (FT)	CULVERT LENGTH (FT)	BARRELS SHAPE MATERIAL	SPAN (FT)	RISE (FT)	MANNING n	INLET TYPE
1	89.00	88.00	420.00	1 CSP	2.00	2.00	.024	CONVENTIONAL
2								
3								
4								
5								
6								

SUMMARY OF CULVERT FLOWS (CFS) FILE: MISTERM2 DATE: 01-05-1995

ELEV (FT)	TOTAL	1	2	3	4	5	6	ROADWAY	ITR
89.00	0	0	0	0	0	0	0	0	1
89.56	1	1	0	0	0	0	0	0	1
89.83	2	2	0	0	0	0	0	0	1
90.03	3	3	0	0	0	0	0	0	1
90.22	4	4	0	0	0	0	0	0	1
90.40	5	5	0	0	0	0	0	0	1
90.57	5	5	0	0	0	0	0	0	1
90.76	6	6	0	0	0	0	0	0	1
91.58	7	7	0	0	0	0	0	0	1
92.00	8	8	0	0	0	0	0	0	1
92.47	9	9	0	0	0	0	0	0	1
97.00	15	15	0	0	0	0	0	OVERTOPPING	

SUMMARY OF ITERATIVE SOLUTION ERRORS FILE: MISTERM2 DATE: 01-05-1995

HEAD ELEV(FT)	HEAD ERROR(FT)	TOTAL FLOW(CFS)	FLOW ERROR(CFS)	% FLOW ERROR
89.00	0.00	0	0	0.00
89.56	0.00	1	0	0.00
89.83	0.00	2	0	0.00
90.03	0.00	3	0	0.00
90.22	0.00	4	0	0.00
90.40	0.00	5	0	0.00
90.57	0.00	5	0	0.00
90.76	0.00	6	0	0.00
91.58	0.00	7	0	0.00
92.00	0.00	8	0	0.00
92.47	0.00	9	0	0.00

<1> TOLERANCE (FT) = 0.010 <2> TOLERANCE (%) = 1.000

CURRENT DATE: 01-05-1995 FILE DATE: 01-05-1995
CURRENT TIME: 16:50:49 FILE NAME: MISTERM2

PERFORMANCE CURVE FOR CULVERT # 1 - 1 (2 BY 2) CSP

DIS-CHARGE FLOW (cfs)	HEAD-WATER ELEV. (ft)	INLET CONTROL DEPTH (ft)	OUTLET CONTROL DEPTH (ft)	FLOW TYPE <F4>	NORMAL DEPTH (ft)	CRITICAL DEPTH (ft)	OUTLET VEL. (fps)	OUTLET DEPTH (ft)	TAILWATER VEL. (fps)	TAILWATER DEPTH (ft)
0	89.00	0.00	0.00	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
1	89.56	0.44	0.56	2-M2c	0.52	0.31	2.80	0.31	1.68	0.22
2	89.83	0.63	0.83	2-M2c	0.75	0.46	3.30	0.46	2.10	0.32
3	90.03	0.80	1.03	2-M2c	0.94	0.57	3.66	0.57	2.37	0.41
4	90.22	0.94	1.22	2-M2c	1.12	0.66	3.98	0.66	2.58	0.47
5	90.40	1.07	1.40	2-M2c	1.30	0.74	4.24	0.74	2.75	0.53
5	90.57	1.19	1.57	2-M2c	1.49	0.82	4.47	0.82	2.89	0.59
6	90.76	1.30	1.76	2-M2c	1.77	0.88	4.70	0.88	3.02	0.64
7	91.58	1.40	2.58	6-FFn	2.00	0.95	2.29	2.00	3.14	0.68
8	92.00	1.50	3.00	6-FFn	2.00	1.01	2.58	2.00	3.24	0.72
9	92.47	1.60	3.47	6-FFn	2.00	1.07	2.86	2.00	3.33	0.76

El. inlet face invert 89.00 ft El. outlet invert 88.00 ft
El. inlet throat invert 0.00 ft El. inlet crest 0.00 ft

***** SITE DATA ***** CULVERT INVERT **********

INLET STATION (FT)	0.00
INLET ELEVATION (FT)	89.00
OUTLET STATION (FT)	420.00
OUTLET ELEVATION (FT)	88.00
NUMBER OF BARRELS	1
SLOPE (V-FT/H-FT)	0.0024
CULVERT LENGTH ALONG SLOPE (FT)	420.00

***** CULVERT DATA SUMMARY **********

BARREL SHAPE	CIRCULAR
BARREL DIAMETER	2.00 FT
BARREL MATERIAL	CORRUGATED STEEL
BARREL MANNING'S N	0.024
INLET TYPE	CONVENTIONAL
INLET EDGE AND WALL	MITERED TO CONFORM TO SLOPE
INLET DEPRESSION	NONE

CURRENT DATE: 01-05-1995 FILE DATE: 01-05-1995
CURRENT TIME: 16:50:49 FILE NAME: MISTERM2

TAILWATER

******* REGULAR CHANNEL CROSS SECTION ***************

BOTTOM WIDTH (FT)	2.00
SIDE SLOPE H/V (X:1)	2.0
CHANNEL SLOPE V/H (FT/FT)	0.010
MANNING'S N (.01-0.1)	0.028
CHANNEL INVERT ELEVATION (FT)	88.00
CULVERT NO.1 OUTLET INVERT ELEVATION	88.00 FT

******* UNIFORM FLOW RATING CURVE FOR DOWNSTREAM CHANNEL

FLOW (CFS)	W.S.E. (FT)	FROUDE NUMBER	DEPTH (FT)	VEL. (FPS)	SHEAR (PSF)
0.00	88.00	0.000	0.00	0.00	0.00
0.90	88.22	0.634	0.22	1.68	0.14
1.80	88.32	0.650	0.32	2.10	0.20
2.70	88.41	0.656	0.41	2.37	0.25
3.60	88.47	0.660	0.47	2.58	0.30
4.50	88.53	0.663	0.53	2.75	0.33
5.40	88.59	0.666	0.59	2.89	0.37
6.30	88.64	0.667	0.64	3.02	0.40
7.20	88.68	0.669	0.68	3.14	0.43
8.10	88.72	0.670	0.72	3.24	0.45
9.00	88.76	0.672	0.76	3.33	0.48

ROADWAY OVERTOPPING DATA

ROADWAY SURFACE	GRAVEL
EMBANKMENT TOP WIDTH (FT)	8.00
CREST LENGTH (FT)	300.00
OVERTOPPING CREST ELEVATION (FT)	97.00

Pipe From Pond 1 to Pond 2

CURRENT DATE: 01-05-1995
CURRENT TIME: 16:35:50

FILE DATE: 01-05-1995
FILE NAME: MISTERM

FHWA CULVERT ANALYSIS
HY-8, VERSION 4.3

CULV	SITE DATA			CULVERT SHAPE, MATERIAL, INLET				
	INLET ELEV. (FT)	OUTLET ELEV. (FT)	CULVERT LENGTH (FT)	BARRELS SHAPE MATERIAL	SPAN (FT)	RISE (FT)	MANNING n	INLET TYPE
1	92.00	91.00	210.00	1 CSP	3.00	3.00	.024	CONVENTIONAL
2								
3								
4								
5								
6								

SUMMARY OF CULVERT FLOWS (CFS) FILE: MISTERM DATE: 01-05-1995

ELEV (FT)	TOTAL	1	2	3	4	5	6	ROADWAY	ITR
92.00	0	0	0	0	0	0	0	0	1
93.10	5	5	0	0	0	0	0	0	1
93.61	10	10	0	0	0	0	0	0	1
94.02	14	14	0	0	0	0	0	0	1
94.41	19	19	0	0	0	0	0	0	1
94.74	24	24	0	0	0	0	0	0	1
95.82	29	29	0	0	0	0	0	0	1
96.47	34	34	0	0	0	0	0	0	1
97.00	37	37	0	0	0	0	0	0	1
98.00	43	43	0	0	0	0	0	0	8
98.03	48	43	0	0	0	0	0	5	12
98.00	43	43	0	0	0	0	0	OVERTOPPING	

SUMMARY OF ITERATIVE SOLUTION ERRORS FILE: MISTERM DATE: 01-05-1995

HEAD ELEV(FT)	HEAD ERROR(FT)	TOTAL FLOW(CFS)	FLOW ERROR(CFS)	% FLOW ERROR
92.00	0.00	0	0	0.00
93.10	0.00	5	0	0.00
93.61	0.00	10	0	0.00
94.02	0.00	14	0	0.00
94.41	0.00	19	0	0.00
94.74	0.00	24	0	0.00
95.82	0.00	29	0	0.00
96.47	0.00	34	0	0.00
97.00	0.00	37	0	0.00
98.00	-0.00	43	0	0.97
98.03	-0.00	48	0	0.92

<1> TOLERANCE (FT) = 0.010 <2> TOLERANCE (%) = 1.000

CURRENT DATE: 01-05-1995 FILE DATE: 01-05-1995
CURRENT TIME: 16:35:50 FILE NAME: MISTERM

PERFORMANCE CURVE FOR CULVERT # 1 - 1 (3 BY 3) CSP

DIS-CHARGE FLOW (cfs)	HEAD-WATER ELEV. (ft)	INLET CONTROL DEPTH (ft)	OUTLET CONTROL DEPTH (ft)	FLOW TYPE <F4>	NORMAL DEPTH (ft)	CRITICAL DEPTH (ft)	OUTLET VEL. (fps)	OUTLET DEPTH (ft)	TAILWATER VEL. (fps)	TAILWATER DEPTH (ft)
0	92.00	0.00	0.00	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
5	93.10	1.04	1.10	2-M2c	0.89	0.67	4.00	0.67	2.53	0.44
10	93.61	1.46	1.61	2-M2c	1.29	0.97	4.83	0.97	3.09	0.63
14	94.02	1.83	2.02	2-M2c	1.63	1.21	5.41	1.21	3.45	0.78
19	94.41	2.17	2.41	2-M2c	1.98	1.40	5.94	1.40	3.73	0.90
24	94.74	2.50	2.74	2-M2c	2.36	1.57	6.39	1.57	3.97	1.01
29	95.82	2.83	3.82	6-FFn	3.00	1.73	4.07	3.00	4.16	1.10
34	96.47	3.18	4.47	6-FFn	3.00	1.88	4.75	3.00	4.34	1.18
37	97.00	3.44	5.00	6-FFn	3.00	1.97	5.23	3.00	4.45	1.24
43	98.00	3.91	6.00	6-FFn	3.00	2.13	6.04	3.00	4.63	1.33
43	98.03	3.93	6.03	6-FFn	3.00	2.13	6.07	3.00	4.76	1.40

El. inlet face invert 92.00 ft El. outlet invert 91.00 ft
El. inlet throat invert 0.00 ft El. inlet crest 0.00 ft

***** SITE DATA ***** CULVERT INVERT **********

INLET STATION (FT)	0.00
INLET ELEVATION (FT)	92.00
OUTLET STATION (FT)	210.00
OUTLET ELEVATION (FT)	91.00
NUMBER OF BARRELS	1
SLOPE (V-FT/H-FT)	0.0048
CULVERT LENGTH ALONG SLOPE (FT)	210.00

***** CULVERT DATA SUMMARY **********

BARREL SHAPE	CIRCULAR
BARREL DIAMETER	3.00 FT
BARREL MATERIAL	CORRUGATED STEEL
BARREL MANNING'S N	0.024
INLET TYPE	CONVENTIONAL
INLET EDGE AND WALL	THIN EDGE PROJECTING
INLET DEPRESSION	NONE

CURRENT DATE: 01-05-1995 FILE DATE: 01-05-1995
CURRENT TIME: 16:35:50 FILE NAME: MISTERM

TAILWATER

******* REGULAR CHANNEL CROSS SECTION **********

BOTTOM WIDTH (FT)	3.00
SIDE SLOPE H/V (X:1)	3.0
CHANNEL SLOPE V/H (FT/FT)	0.010
MANNING'S N (.01-0.1)	0.028
CHANNEL INVERT ELEVATION (FT)	91.00
CULVERT NO.1 OUTLET INVERT ELEVATION	91.00 FT

******* UNIFORM FLOW RATING CURVE FOR DOWNSTREAM CHANNEL

FLOW (CFS)	W.S.E. (FT)	FROUDE NUMBER	DEPTH (FT)	VEL. (FPS)	SHEAR (PSF)
0.00	91.00	0.000	0.00	0.00	0.00
4.80	91.44	0.671	0.44	2.53	0.27
9.60	91.63	0.683	0.63	3.09	0.40
14.40	91.78	0.689	0.78	3.45	0.49
19.20	91.90	0.693	0.90	3.73	0.56
24.00	92.01	0.697	1.01	3.97	0.63
28.80	92.10	0.700	1.10	4.16	0.69
33.60	92.18	0.703	1.18	4.34	0.74
37.00	92.24	0.705	1.24	4.45	0.77
43.20	92.33	0.707	1.33	4.63	0.83
48.00	92.40	0.709	1.40	4.76	0.87

ROADWAY OVERTOPPING DATA

ROADWAY SURFACE	GRAVEL
EMBANKMENT TOP WIDTH (FT)	8.00
CREST LENGTH (FT)	300.00
OVERTOPPING CREST ELEVATION (FT)	98.00

Pipe From Pond 1 to Pond 2

CURRENT DATE: 01-05-1995 FILE DATE: 01-05-1995
CURRENT TIME: 16:37:46 FILE NAME: MISTERM

FHWA CULVERT ANALYSIS
HY-8, VERSION 4.3

CULV	SITE DATA			CULVERT SHAPE, MATERIAL, INLET				
	INLET ELEV. (FT)	OUTLET ELEV. (FT)	CULVERT LENGTH (FT)	BARRELS SHAPE MATERIAL	SPAN (FT)	RISE (FT)	MANNING n	INLET TYPE
1	92.00	91.00	210.00	1 CMPA	3.50	2.42	.025	CONVENTIONAL
2								
3								
4								
5								
6								

SUMMARY OF CULVERT FLOWS (CFS) FILE: MISTERM DATE: 01-05-1995

ELEV (FT)	TOTAL	1	2	3	4	5	6	ROADWAY	ITR
92.00	0	0	0	0	0	0	0	0	1
92.87	5	5	0	0	0	0	0	0	1
93.29	10	10	0	0	0	0	0	0	1
93.64	14	14	0	0	0	0	0	0	1
94.04	19	19	0	0	0	0	0	0	1
95.09	24	24	0	0	0	0	0	0	1
95.83	29	29	0	0	0	0	0	0	1
96.70	34	34	0	0	0	0	0	0	1
97.40	37	37	0	0	0	0	0	0	1
97.89	43	39	0	0	0	0	0	0	30
98.05	48	40	0	0	0	0	0	8	21
98.00	40	40	0	0	0	0	0	OVERTOPPING	

SUMMARY OF ITERATIVE SOLUTION ERRORS FILE: MISTERM DATE: 01-05-1995

HEAD ELEV(FT)	HEAD ERROR(FT)	TOTAL FLOW(CFS)	FLOW ERROR(CFS)	% FLOW ERROR
92.00	0.00	0	0	0.00
92.87	0.00	5	0	0.00
93.29	0.00	10	0	0.00
93.64	0.00	14	0	0.00
94.04	0.00	19	0	0.00
95.09	0.00	24	0	0.00
95.83	0.00	29	0	0.00
96.70	0.00	34	0	0.00
97.40	0.00	37	0	0.00
97.89	-0.01	43	4	9.24
98.05	-0.00	48	0	0.92

<1> TOLERANCE (FT) = 0.010 <2> TOLERANCE (%) = 1.000

CURRENT DATE: 01-05-1995 FILE DATE: 01-05-1995
CURRENT TIME: 16:37:46 FILE NAME: MISTERM

PERFORMANCE CURVE FOR CULVERT # 1 - 1 (3.5 BY 2.416667) CMPA

DIS-CHARGE FLOW (cfs)	HEAD-WATER ELEV. (ft)	INLET CONTROL DEPTH (ft)	OUTLET CONTROL DEPTH (ft)	FLOW TYPE <F4>	NORMAL DEPTH (ft)	CRITICAL DEPTH (ft)	OUTLET VEL. (fps)	OUTLET DEPTH (ft)	TAILWATER VEL. (fps)	TAILWATER DEPTH (ft)
0	92.00	0.00	0.00	0-NF	0.00	0.00	0.00	0.00	0.00	0.00
5	92.87	0.80	0.87	2-M2c	0.67	0.50	3.62	0.50	2.53	0.44
10	93.29	1.19	1.29	2-M2c	1.01	0.74	4.47	0.74	3.09	0.63
14	93.64	1.53	1.64	2-M2c	1.32	0.93	5.10	0.93	3.45	0.78
19	94.04	1.84	2.04	2-M2c	1.66	1.10	5.67	1.10	3.73	0.90
24	95.09	2.14	3.09	6-FFn	2.42	1.25	3.55	2.42	3.97	1.01
29	95.83	2.44	3.83	6-FFn	2.42	1.39	4.26	2.42	4.16	1.10
34	96.70	2.78	4.70	6-FFn	2.42	1.51	4.97	2.42	4.34	1.18
37	97.40	3.05	5.40	6-FFn	2.42	1.60	5.47	2.42	4.45	1.24
39	97.89	3.24	5.89	6-FFn	2.42	1.65	5.80	2.42	4.63	1.33
40	98.05	3.30	6.05	6-FFn	2.42	1.67	5.90	2.42	4.76	1.40

El. inlet face invert 92.00 ft El. outlet invert 91.00 ft
El. inlet throat invert 0.00 ft El. inlet crest 0.00 ft

***** SITE DATA ***** CULVERT INVERT **********

INLET STATION (FT)	0.00
INLET ELEVATION (FT)	92.00
OUTLET STATION (FT)	210.00
OUTLET ELEVATION (FT)	91.00
NUMBER OF BARRELS	1
SLOPE (V-FT/H-FT)	0.0048
CULVERT LENGTH ALONG SLOPE (FT)	210.00

***** CULVERT DATA SUMMARY **********

BARREL SHAPE	PIPE ARCH
BARREL SPAN	3.50 FT
BARREL RISE	2.42 FT
BARREL MATERIAL	STEEL OR ALUMINUM
BARREL MANNING'S N	0.025
INLET TYPE	CONVENTIONAL
INLET EDGE AND WALL	PROJECTING
INLET DEPRESSION	NONE

CURRENT DATE: 01-05-1995
CURRENT TIME: 16:37:46

FILE DATE: 01-05-1995
FILE NAME: MISTERM

TAILWATER

******* REGULAR CHANNEL CROSS SECTION ****************

BOTTOM WIDTH (FT)	3.00
SIDE SLOPE H/V (X:1)	3.0
CHANNEL SLOPE V/H (FT/FT)	0.010
MANNING'S N (.01-0.1)	0.028
CHANNEL INVERT ELEVATION (FT)	91.00
CULVERT NO.1 OUTLET INVERT ELEVATION	91.00 FT

******* UNIFORM FLOW RATING CURVE FOR DOWNSTREAM CHANNEL

FLOW (CFS)	W.S.E. (FT)	FROUDE NUMBER	DEPTH (FT)	VEL. (FPS)	SHEAR (PSF)
0.00	91.00	0.000	0.00	0.00	0.00
4.80	91.44	0.671	0.44	2.53	0.27
9.60	91.63	0.683	0.63	3.09	0.40
14.40	91.78	0.689	0.78	3.45	0.49
19.20	91.90	0.693	0.90	3.73	0.56
24.00	92.01	0.697	1.01	3.97	0.63
28.80	92.10	0.700	1.10	4.16	0.69
33.60	92.18	0.703	1.18	4.34	0.74
37.00	92.24	0.705	1.24	4.45	0.77
43.20	92.33	0.707	1.33	4.63	0.83
48.00	92.40	0.709	1.40	4.76	0.87

ROADWAY OVERTOPPING DATA

ROADWAY SURFACE	GRAVEL
EMBANKMENT TOP WIDTH (FT)	8.00
CREST LENGTH (FT)	300.00
OVERTOPPING CREST ELEVATION (FT)	98.00

PIPEPART"
06-Nov-94
5:39 PM

PIPE FLOWING PARTLY FULL
MISTER M LANDFILL
STORM DRAIN COLLECTION SYSTEM
ROUND PIPE HYDRAULICS

DIAMETER, feet = 1.5000 inch = 18
"n" VALUE = .015
SLOPE, ft/ft = .005 % = .50

DEPTH RATIO	DEPTH feet	FLOW cfs	FLOW gpm	AREA sq ft	VEL fps	* EG feet	FROUDE
0	.0000	0	0	0	0	0	0
.1	.1500	.13	60.51	.09	1.46	.18	.6648909
.2	.3000	.56	253.66	.25	2.24	.38	.7209955
.3	.4500	1.26	567.33	.45	2.83	.57	.7426884
.4	.6000	2.17	976.28	.66	3.29	.77	.7476799
.5	.7500	3.22	1448.50	.88	3.64	.96	.7413158
.6	.9000	4.32	1945.98	1.11	3.91	1.14	.7256534
.7	1.0500	5.39	2425.13	1.32	4.08	1.31	.7015054
.8	1.2000	6.29	2831.82	1.52	4.15	1.47	.6679598
.9	1.3500	6.86	3087.22	1.68	4.10	1.61	.6211732
1	1.5000	6.44	2896.99	1.77	3.64	1.71	.5241894

* Feet above pipe invert

PIPEPART" PIPE FLOWING PARTLY FULL
06-Nov-94 MISTER M LANDFILL
5:39 PM STORM DRAIN COLLECTION SYSTEM
ROUND PIPE HYDRAULICS

DIAMETER, feet = 2.0000 inch = 24
"n" VALUE = .024
SLOPE, ft/ft = .005 % = .50

DEPTH RATIO	DEPTH feet	FLOW cfs	FLOW gpm	AREA sq ft	VEL fps	* EG feet	FROUDE
0	.0000	0	0	0	0	0	0
.1	.2000	.18	81.45	.16	1.11	.22	.4359585
.2	.4000	.76	341.43	.45	1.70	.44	.4727454
.3	.6000	1.70	763.63	.79	2.14	.67	.4869692
.4	.8000	2.92	1314.06	1.17	2.49	.90	.4902420
.5	1.0000	4.33	1949.66	1.57	2.76	1.12	.4860691
.6	1.2000	5.82	2619.27	1.97	2.96	1.34	.4757995
.7	1.4000	7.25	3264.20	2.35	3.09	1.55	.4599661
.8	1.6000	8.47	3811.60	2.69	3.14	1.75	.4379708
.9	1.8000	9.23	4155.36	2.98	3.10	1.95	.4072936
1	2.0000	8.67	3899.32	3.14	2.76	2.12	.3437028

* Feet above pipe invert

WEIR RATING CALCULATION 01-Nov-94
PROJECT: MISTER M SPILLWAY 9:44:56 AM
"WEIR"

WEIR LENGTH, ft = 9.424778 inches = 113.0973355
WEIR CREST EL,ft = 4191
HEAD INC = .1
COEFICIENT = 3.1
WID APPROACH, ft = 20
APPROACH INV = 4188

WSE ft	HEAD ft	APP VEL fps	APP HEAD fps	FLOW cfs	FLOW gpm
4191.00	0	.00	.00	.00	0
4191.10	.1	.00	.00	.92	416
4191.20	.2	.00	.00	2.61	1,176
4191.30	.3	.00	.00	4.80	2,160
4191.40	.4	.00	.00	7.39	3,326
4191.50	.5	.00	.00	10.33	4,648
4191.60	.6	.00	.00	13.58	6,110
4191.70	.7	.00	.00	17.11	7,700
4191.80	.8	.00	.00	20.91	9,408
4191.90	.9	.00	.00	24.95	11,226
4192.00	1	.00	.00	29.22	13,148
4192.10	1.1	.00	.00	33.71	15,168
4192.20	1.2	.00	.00	38.41	17,283
4192.30	1.3	.00	.00	43.31	19,488
4192.40	1.4	.00	.00	48.40	21,779
4192.50	1.5	.00	.00	53.67	24,154
4192.60	1.6	.00	.00	59.13	26,609
4192.70	1.7	.00	.00	64.76	29,142
4192.80	1.8	.00	.00	70.56	31,751
4192.90	1.9	.00	.00	76.52	34,433
4193.00	2	.00	.00	82.64	37,187
4193.10	2.1	.00	.00	88.91	40,011
4193.20	2.2	.00	.00	95.34	42,902
4193.30	2.3	.00	.00	101.91	45,860
4193.40	2.4	.00	.00	108.63	48,883
4193.50	2.5	.00	.00	115.49	51,970
4193.60	2.6	.00	.00	122.49	55,120
4193.70	2.7	.00	.00	129.62	58,330
4193.80	2.8	.00	.00	136.89	61,600
4193.90	2.9	.00	.00	144.29	64,930
4194.00	3	.00	.00	151.82	68,317

PIPEPART" PIPE FLOWING PARTLY FULL
01-Nov-94 MISTER M LANDFILL
10:58 AM STORM DRAIN COLLECTION SYSTEM
ROUND PIPE HYDRAULICS

DIAMETER, feet = 3.000 inch = 36
"n" VALUE = .024
SLOPE, ft/ft = .01 % = 1.00

DEPTH RATIO	DEPTH feet	FLOW cfs	FLOW gpm	AREA sq ft	VEL fps	* EG feet	FROUDE
0	.000	0	0	0	0	0	0
.1	.300	.75	339.60	.37	2.05	.37	.6596248
.2	.600	3.16	1423.57	1.01	3.14	.75	.7152851
.3	.900	7.08	3183.91	1.78	3.97	1.14	.7368062
.4	1.200	12.18	5478.93	2.64	4.61	1.53	.7417581
.5	1.500	18.06	8129.04	3.53	5.11	1.91	.7354444
.6	1.800	24.27	10920.94	4.43	5.48	2.27	.7199060
.7	2.100	30.24	13609.94	5.28	5.72	2.61	.6959493
.8	2.400	35.32	15892.33	6.06	5.83	2.93	.6626695
.9	2.700	38.50	17325.62	6.70	5.75	3.21	.6162534
1	3.000	36.13	16258.08	7.07	5.11	3.41	.5200377

* Feet above pipe invert

***** IRRIGATED CROP CONSUMPTIVE USE *****
(Using SCS Blaney Criddle Procedure)

Job Name: MISTER M LANDFILL
By: KWS
Date: Tue Oct 18 1994
Location: LEWISTOWN, MT
Weather Station Name: LEWISTOWN 10S
Job Elevation Above Sea Level = 4900 feet

Crop: Alfalfa
Start Growth Date = May 17
End Growth Date = September 25

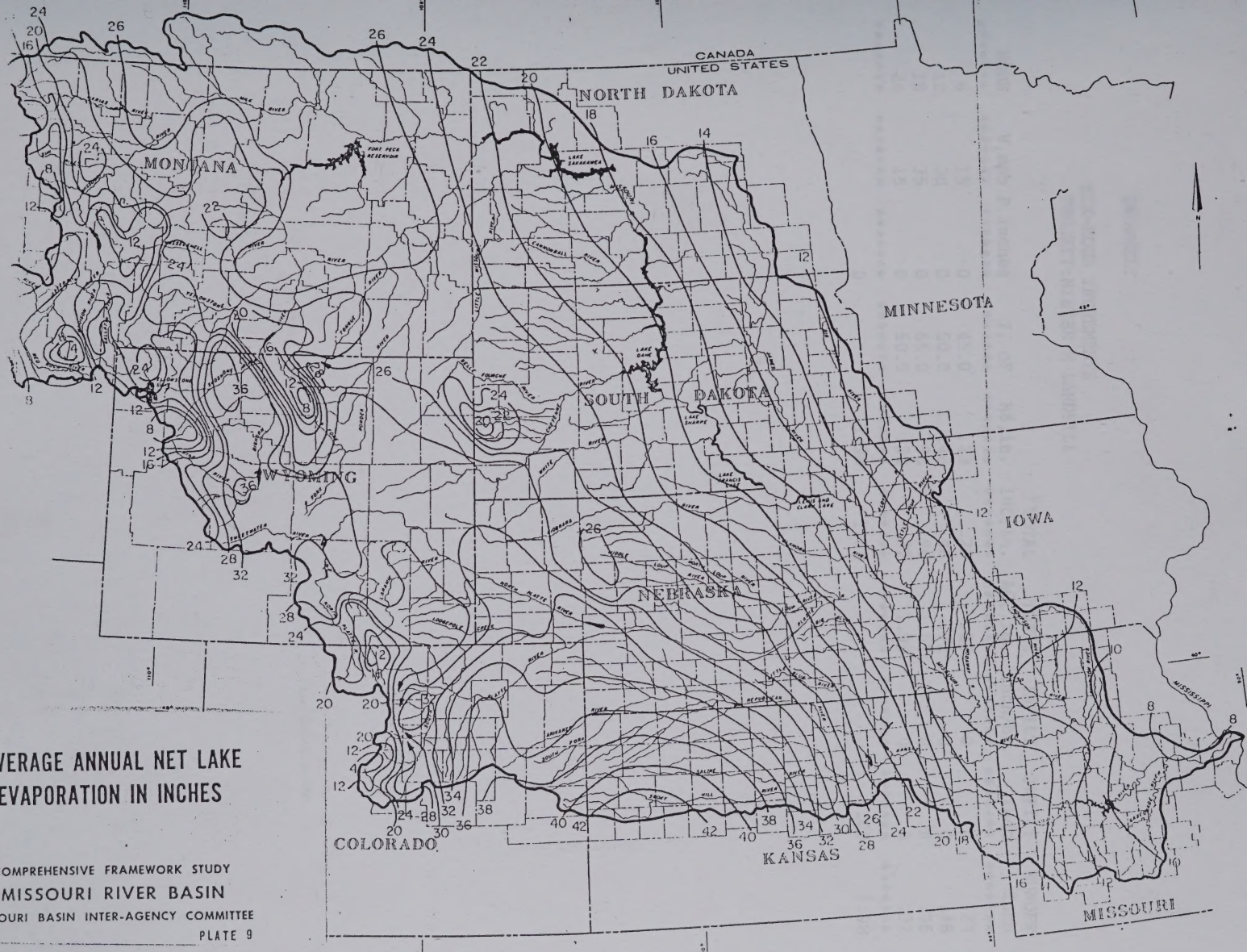
Net Irrigation Application = 1.00 inches
Carryover Moisture Used at Beginning of Season = 0.00 inches
Carryover Moisture to be Used at End of Season = 0.00 inches

Month	Monthly Consumptive Use (3) (inches)	80% Chance (2) Dry Year Effect. Precip-itation (inches)	80% Chance (2) Dry Year Net Irr. Require-ments (1) (inches)	50% Chance (2) Normal Year Effect. Precip-itation (inches)	50% Chance (2) Normal Year Net Irr. Require-ments (1) (inches)	Average Daily Conspt. Use (inches)	Peak Daily Consumpt Use (inches)
January							
February							
March							
April							
May	1.74	0.71	1.04	0.87	0.87	0.12	
June	5.01	1.57	3.44	1.95	3.06	0.17	0.197
July	7.12	1.10	6.02	1.36	5.76	0.23	0.289
August	5.94	0.99	4.96	1.23	4.72	0.19	0.237
September	2.78	0.69	2.09	0.86	1.92	0.11	
October							
November							
December							
TOTALS	22.59	5.05	17.54	6.27	16.33		

(1) The net irrigation requirements include carryover moisture to be used at the beginning of the season and allows for carryover planned to be used at the end of the growing season.

(2) For 80 pecent chance occurrance, growing season effective precipitation will be equaled or exceeded 8 out of 10 years. For 50 percent chance occurrance, effective precipitation will be equaled or exceeded 1 out of 2 years.

(3) Consumptive use is corrected upwards about 3 percent per 1000 feet for elevations more than 1000 feet above sea level.



AVERAGE ANNUAL NET LAKE EVAPORATION IN INCHES

COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

MISSOURI BASIN INTER-AGENCY COMMITTEE

PLATE 9

SNOWMELT

SIX-HOUR INCREMENTS
PROJECT:MISTER M LANDFILL

HOUR	V,mph	P,inches	T, oF	M6,in.	TOTAL INC,in.	TOTAL ACC,in.	INFILT inch/hr	INFILT inch	RUNOFF inch
*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
6	15	0	45.0	.23	.23	.23	0	0	.23
12	30	0	50.0	.48	.48	.71	0	0	.48
18	35	0	65.0	.96	.96	1.67	0	0	.96
24	15	0	50.0	.32	.32	1.98	0	0	.32
*******	*******	*******	*******	*******	*******	*******	*******	*******	*******
		0		1.98	1.98			.00	1.98

APPENDIX E

GEOTECHNICAL STABILITY ANALYSIS

Robert W. Gillespie, P.E.
Consulting Geotechnical Engineer

Registered in: Montana Wyoming North Dakota South Dakota Idaho Nevada Maine New Hampshire Massachusetts Vermont Florida

03 January 1995

Mr. Kenneth Salo, P.E.
Morrison-Maierle/CSSA
910 Helena Avenue
Helena, MT 59604

Subject: Stability Analyses for Storm Water Ponds
Mister M Landfill Site
Lewistown, Montana
Project No. 579-03

Dear Ken:

Attached please find our stability analyses for the above referenced project. The analyses were performed to conform to current state regulations regarding storm water detention facilities. Data gathered during our site characterization studies were utilized in the analyses as were the pond configurations contained on your Sheet Nos. 1 and 2 accompanying the storm water analysis.

Briefly, the maximum section is stable under static and dynamic conditions using conservation strength values. Shear strength loss could approach 50 percent while still maintaining adequate factors of safety. The stability of soil cover on the pvc liner was also evaluated for a pure friction case, and more reasonably, an adhesion case.

If you have any questions or if we may be of further service, please contact us.

Very truly yours,

Robert W. Gillespie, P.E.

MONTANA
ROBERT W.
GILLESPIE
4943 E
REGISTERED
PROFESSIONAL ENGINEER

RWG:ci
cc: Mister M Disposal, Inc.

P. O. Box 876
Lewistown, Montana 59457

APPENDIX E

STABILITY ANALYSES

INTRODUCTION

In accordance with the requirement of current Montana regulations, stability analyses of the storm water pond embankments have been performed for applicable cases. These include:

- soil cover over pvc liner treated as a free body;

- static analysis of embankment at northwest corner of Pond 2 which is the highest and should therefore represent the critical section; and

- psuedostatic analysis of the same section to simulate earthquake loading.

The analyses are presented in separate sections and are supported by calculations, graphics, and computer output as appropriate.

Soil Cover Over Liner

The generalized cross-section is presented as Figure E-1 and illustrates both Ponds 1 and 2. The soil cover will be a silty clay with moderate to high plasticity and only minor amounts of sand size particles. The primary resisting mechanism for resistance to sliding of the soil along the liner will be adhesion. The undrained shear strength of the clay after remolding, moisture conditioning, and compaction will be in the range of 500 to 1,000 psf based on numerous geotechnical studies involving the weathered Kootenai shales. As a comparative study, we treated the clay-liner interface as purely frictional. The analyses are shown on Figure E-2, and indicate that clay soil on the liner should be stable. Once vegetation is established, the stability should increase due to the reinforcement effects of the root mat.

We have also neglected three dimensional effects created by the soil mass of the slope resting against the pond bottom. While this effect is difficult to evaluate effectively, it does exist as illustrated by the number of liners which remain in place with a safety factor of less than one.

Static Analysis of Pond Embankment

The northwest corner of Pond 2 was selected for the analysis because it represents the highest section of either pond (see Figure E-3). It will be in cut for the upper 10 feet and fill for the lower section. Both materials will be moderate to high plasticity silty clay although the undrained shear strength of the fill will be slightly less than that of the natural soil as a result of remolding during placement and compaction. Standard penetration resistance tests, and pocket penetrometer tests from the monitoring well borings were reviewed for strength data. Undrained shear strength for undisturbed clays are in excess of 2,000 psf. Remolded shear

INTRODUCTION

In accordance with the requirements of [illegible] regulations, stability analyses of the ashes water pond embankments have been performed for eight-like cases. These include:

- soil cover over pond liner treated as a free body;

- static analysis of embankment at northwest corner of Pond 2, which is the highest and should therefore represent the critical section, and

- pseudostatic analysis of the same section to simulate earthquake loading.

The analyses are presented in separate sections and are accompanied by calculations, graphics, and computer output as appropriate.

Soil Cover Over Liner

The proposed cross-section is presented as Figure E-1 and illustrates both Pondy 1 and 2. The soil cover will be a silty clay with moderate to high plasticity and only minor amounts of sand and gravel. The primary reasons are for resistance to slipping of the soil along the liner will be adequate. The minimal clay strength of the clay, after consolidation, moisture conditioning, and compaction will be in the range of 500 to 1,000 psf based on numerous geotechnical studies involving the specified borrow sources. As a conservative study, we treated the clay-liner interface as purely frictional. The analyses are shown on Figure E-2, and indicate that clay will not be the liner slipping be stable. Once revegetation is established, the stability should increase due to the root reinforcement effects of the vegetation.

We have also modeled some dynamic effects, caused by the soil mass of the slope resting against the pond bottom. While this effect is difficult to evaluate effectively, it does exist as illustrated by the number of cases which remain in place with a safety factor of less than one.

Static Analysis of Pond Embankment

The northwest corner of Pond 2 was selected for the analysis because it represents the highest section of either pond (see Figure E-3). It will be as low for the cases 10 feet and 20 feet for the lower section. Both materials will be compacted to high plasticity clay (Pondy 1) and the indicated shear strength of the fill will be slightly less than that of the original soil as a result of remolding during placement and compaction. Standard penetration resistance tests and pocket penetrometer tests from the excavation will provide values for attempts data. Indicated shear strength for unsaturated clays are in excess of 2,000 psf. Remolded shear

strength is less than 1500 but greater than 500 psf and is influenced by molding water content at the time of placement and compaction. A value of 1,000 psf is considered reasonable and realistic. Unit weights were derived from the undisturbed Shelby tube samples recovered for permeability testing during the geohydrologic characterization portion of the work. Since ground water is not present within the cut or fill portions of the pond, it has been excluded from the analyses. Although the pond will contain water to El. 4200 feet, release will be slow and a rapid drawdown case should not develop. Therefore, the analyses will center on the static case for full and empty ponds. A summary of the final static configuration is presented on Figure E-4.

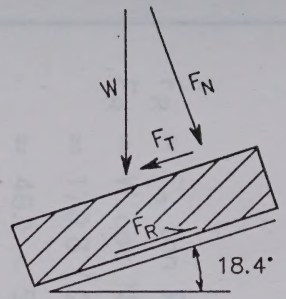
The stability analyses were performed using STABL4 from Princeton University. Static analyses were performed with the pond empty and at flood stage for comparative purposes. Since undrained shear strength was used, the difference in water elevations should be minimal. Results are presented on Figures E-5 and E-6; factors of safety are greater than 2.

Earthquake Analysis

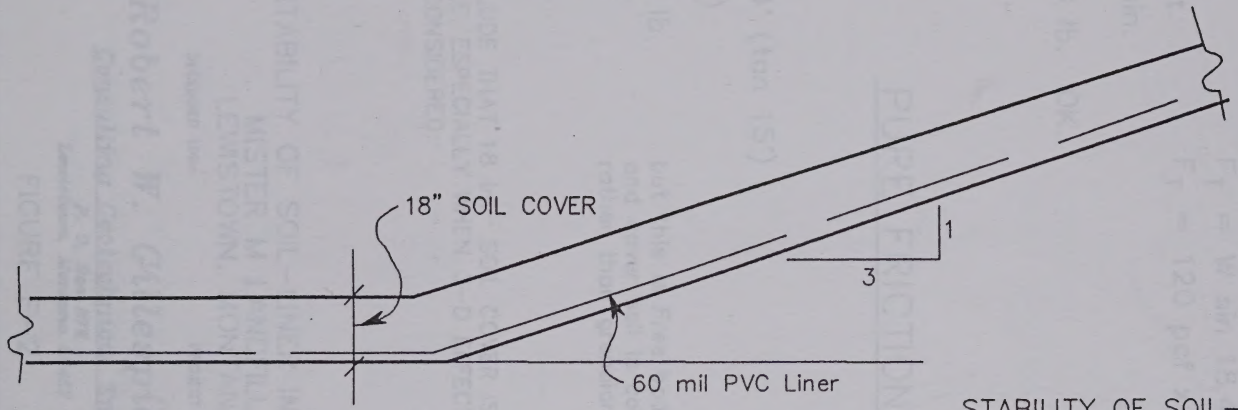
The embankment was evaluated for stability in an earthquake which would typically be associated with seismic zonation for Lewistown. Based on BOCA and SEAONC descriptions and seismic maps, Lewistown is Zone 1 for seismic design purposes. Therefore, horizontal and vertical accelerations associated with an event will be small. Review of the literature suggests that 0.05g and 0.01g are reasonable approximations for the horizontal and vertical accelerations respectively. The same configurations and strength data from the static analyses were used for dynamic analyses. Results are plotted on Figures E-7 and E-8. Again, factors of safety are greater than 2.

Conclusions

The foregoing analyses show that the embankment is stable as configured and could undergo strength losses of up to 50 percent while maintaining factors of safety greater than 1.5, the typical minimum acceptable value.



SOIL–LINER ELEMENT



SCHEMATIC OF POND LINER

NOT TO SCALE

STABILITY OF SOIL–LINER INTERFACE
MISTER M LANDFILL
LEWISTOWN, MONTANA

DECEMBER 1994 PROJECT NO. 579–03

Robert W. Gillespie, P.E.

Consulting Geotechnical Engineer

P. O. Box 876
Lewistown, Montana 59457

FIGURE E–1

PURE ADHESION

$F_R = C_a \times A$

Use $A = 1$ sq. ft.

$C_a = 250$ psf min.

$F_T = W \sin 18.4^\circ$

$F_T = 120$ pcf $\times$ 1.5 ft. $\times$ .32 = 58 lb.

$F_R = 250 >> 58$ lb. OK.

PURE FRICTION

$F_R = F_a \tan \delta$

$F_R = W \cos 18.4^\circ (\tan 15^\circ)$

$= 170.8 (.27)$

$= 46.1 < 58$ lb.

but this is Free body analysis, and cover soil is cohesive rather than granular.

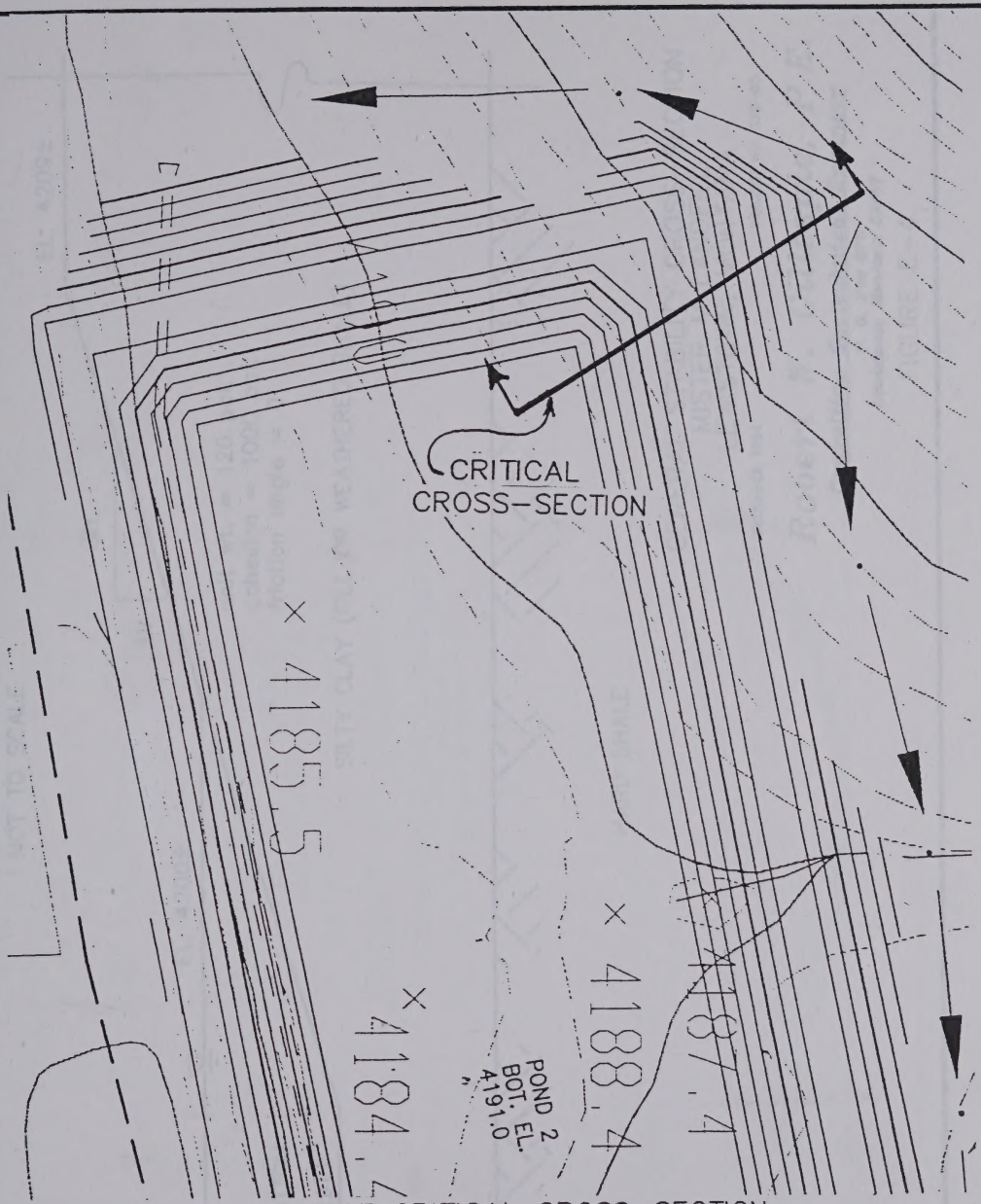
CONCLUDE THAT 18 in. SOIL COVER IS STABLE, ESPECIALLY WHEN 3-D EFFECTS ARE CONSIDERED.

STABILITY OF SOIL-LINER INTERFACE
MISTER M LANDFILL
LEWISTOWN, MONTANA

DECEMBER 1994 PROJECT NO. 579-03

Robert W. Gillespie, P.E.
Consulting Geotechnical Engineer
P. O. Box 876
Lewistown, Montana 59457

FIGURE E-2



LOCUS OF CRITICAL CROSS-SECTION
MISTER M LANDFILL
LEWISTOWN, MONTANA

Source: Dwg. 2 of Run-on/Run-off Control Plan by Morrison-Maierle/CSSA, undated

DECEMBER 1994

PROJECT NO. 579-03

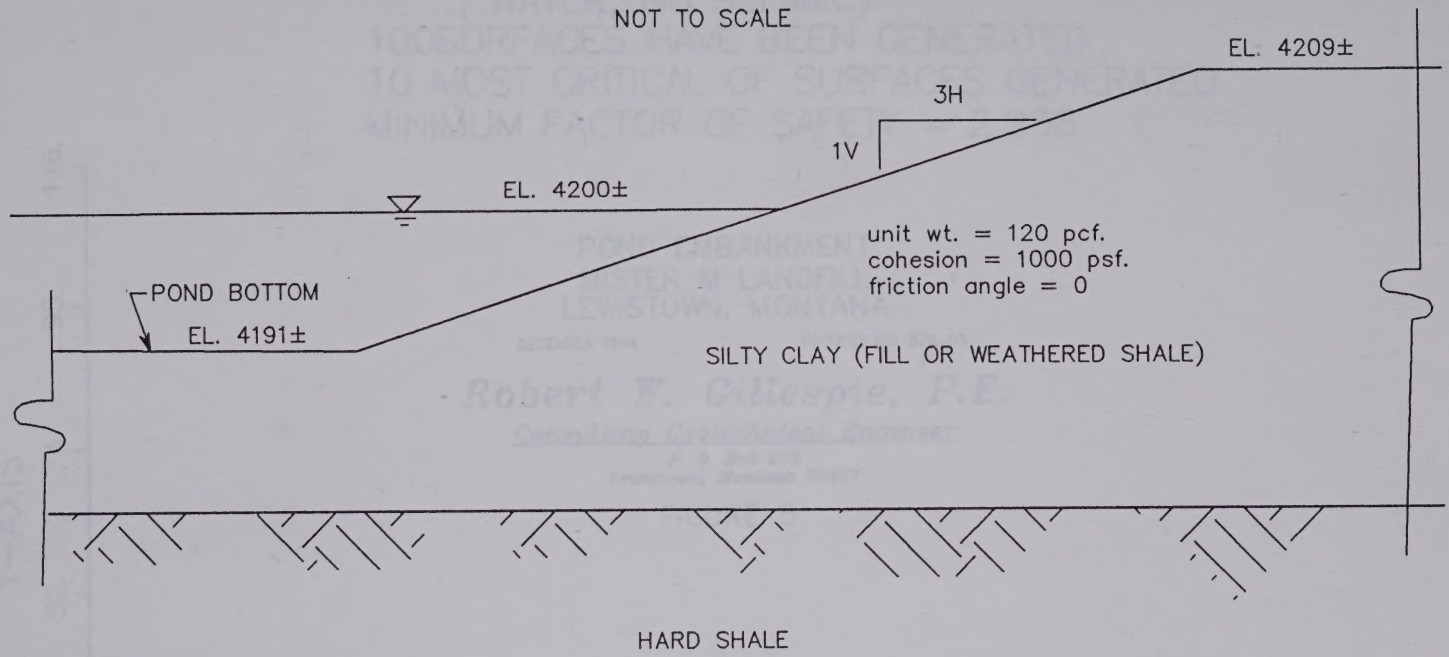
N

Robert W. Gillespie, P.E.
Consulting Geotechnical Engineer
P. O. Box 876
Lewistown, Montana 59457

FIGURE E-3

GENERALIZED STABILITY CROSS-SECTION

NOT TO SCALE



GENERAL STABILITY CROSS-SECTION
MISTER M LANDFILL
LEWISTOWN, MONTANA

DECEMBER 1994 PROJECT NO. 579-03

Robert W. Gillespie, P.E.

Consulting Geotechnical Engineer

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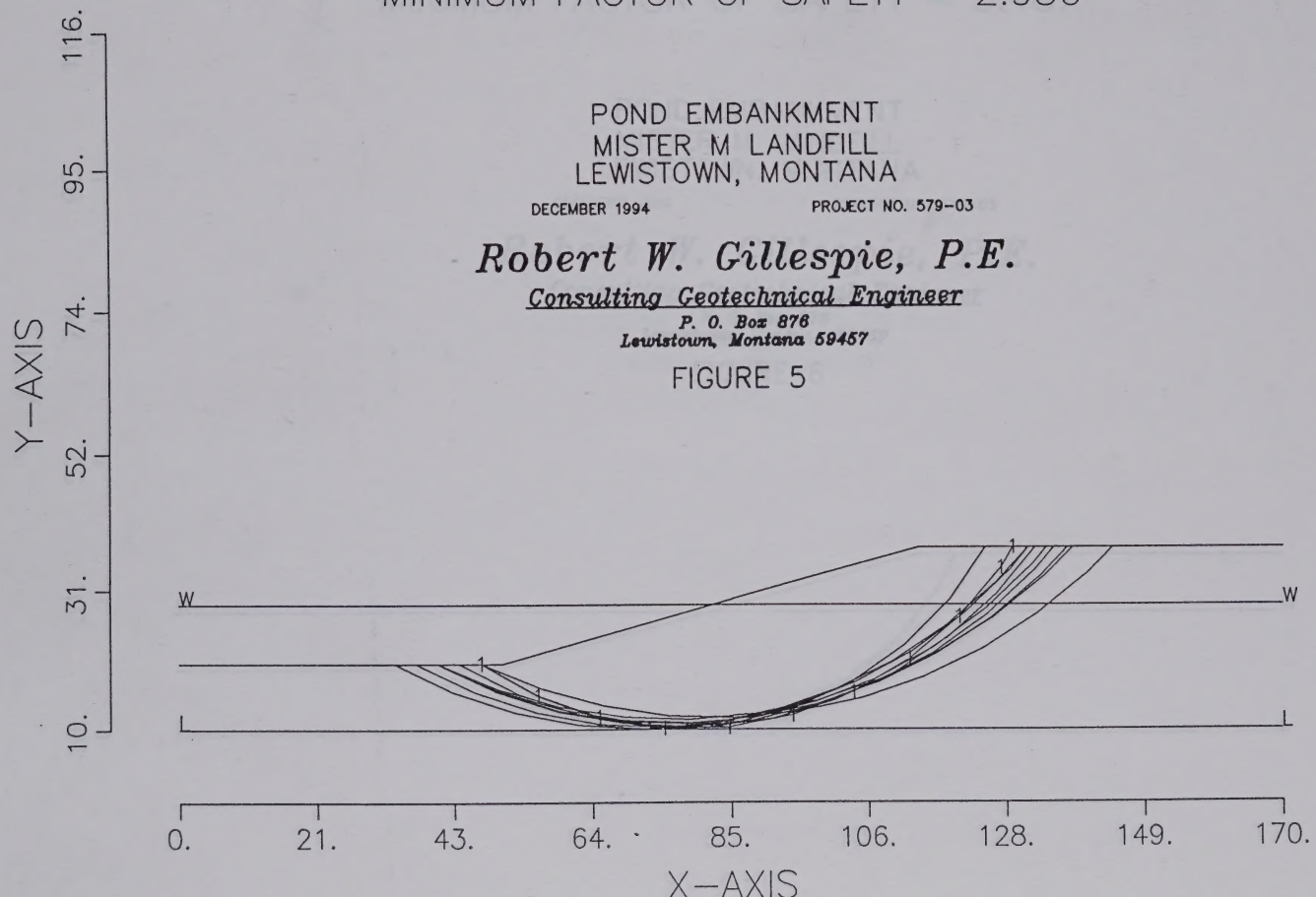
Lewistown, Montana 59457

FIGURE E-4

R. W. Gillespie & Assoc.
Sanford, ME (sn 5112)

MISTER M. LANDFILL POND TRIAL 6 (PHI = 0
, WATER, NO SEISMIC)
100SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 2.936



R. W. Gillespie & Assoc.
Sanford, ME (sn 5112)

MISTER M. LANDFILL POND TRIAL 5 (PHI = 0
, WATER, NO SEISMIC)
100SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 3.487

POND EMBANKMENT
MISTER M LANDFILL
LEWISTOWN, MONTANA

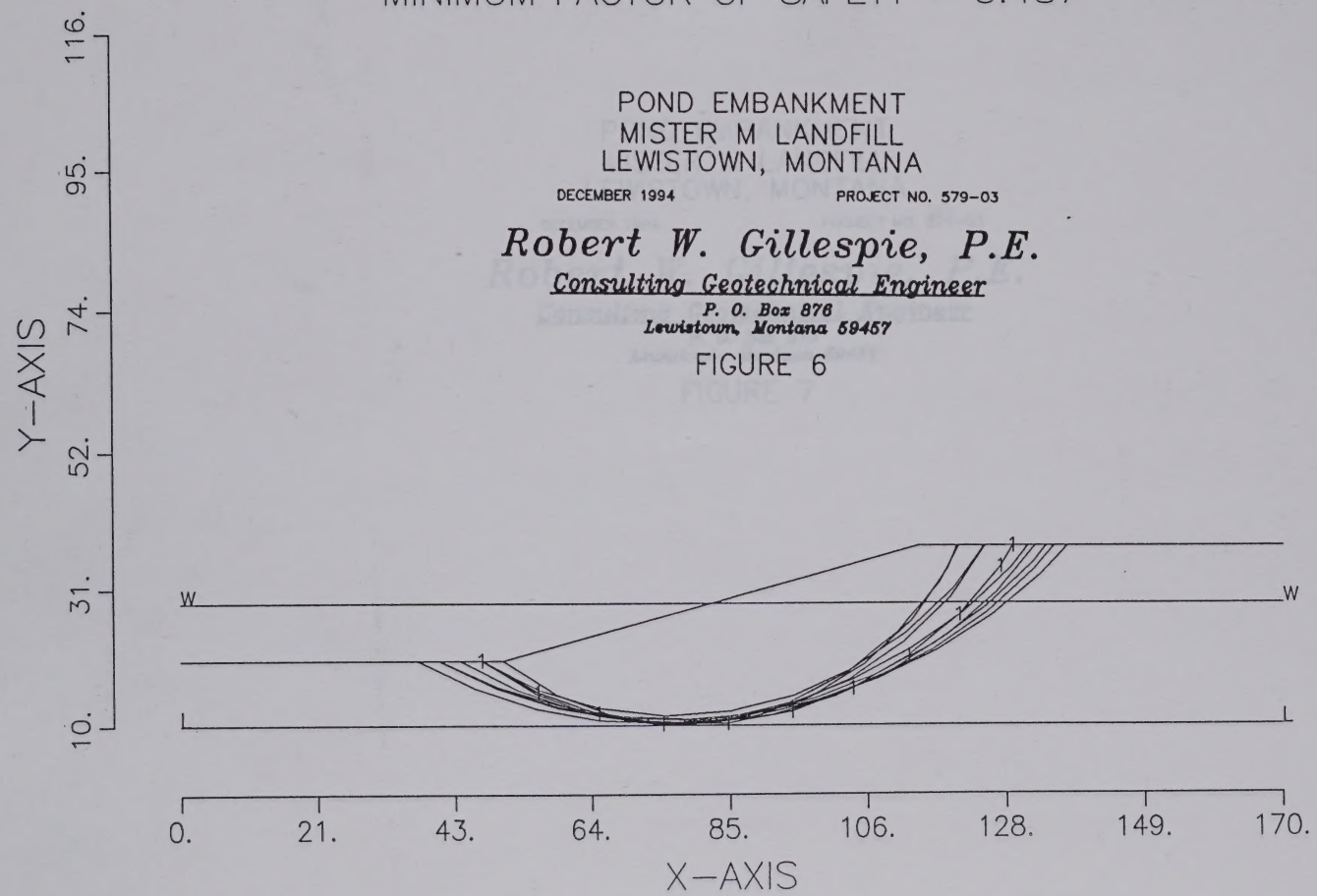
DECEMBER 1994 PROJECT NO. 579-03

Robert W. Gillespie, P.E.

Consulting Geotechnical Engineer

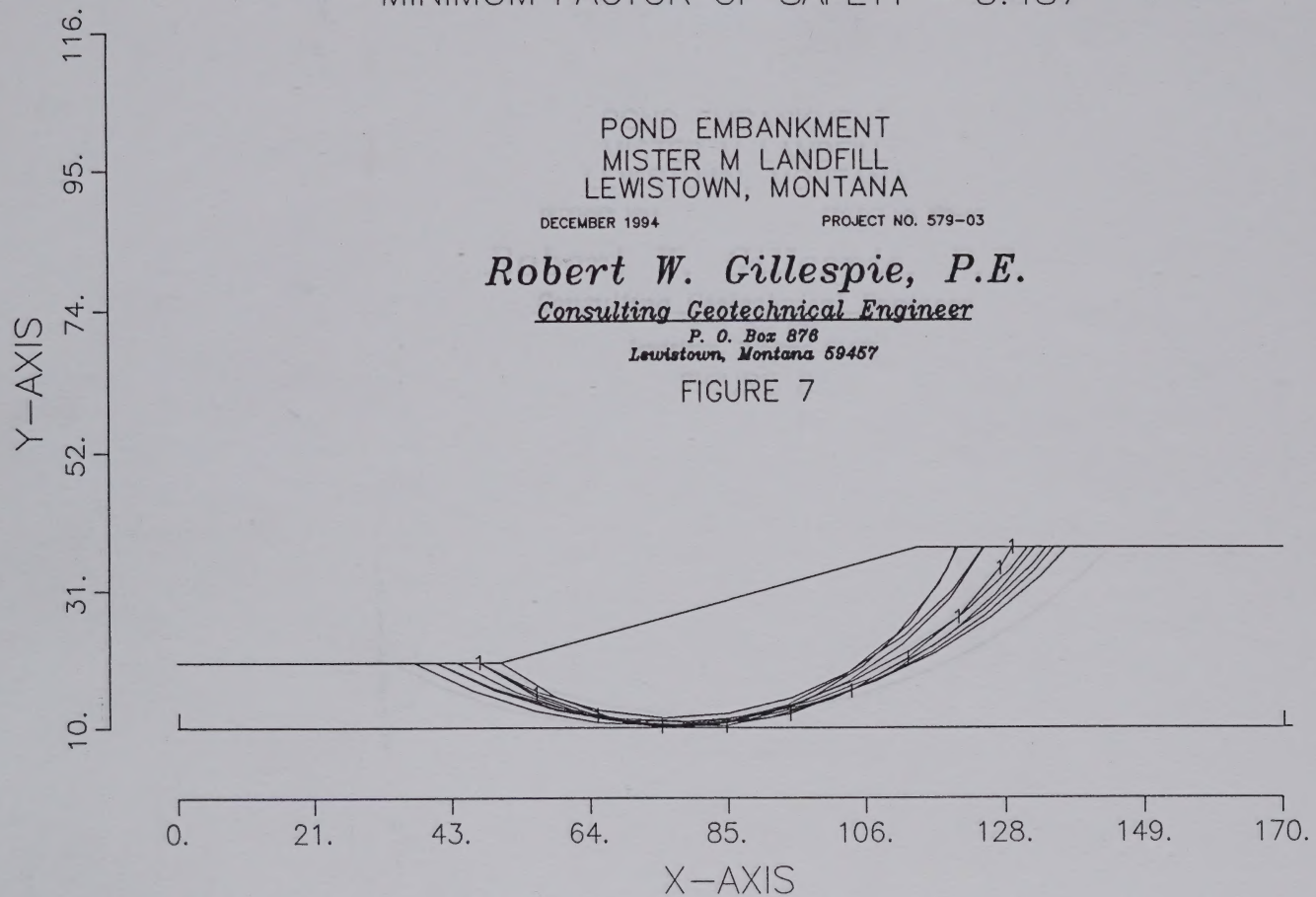
P. O. Box 876
Lewistown, Montana 59457

FIGURE 6



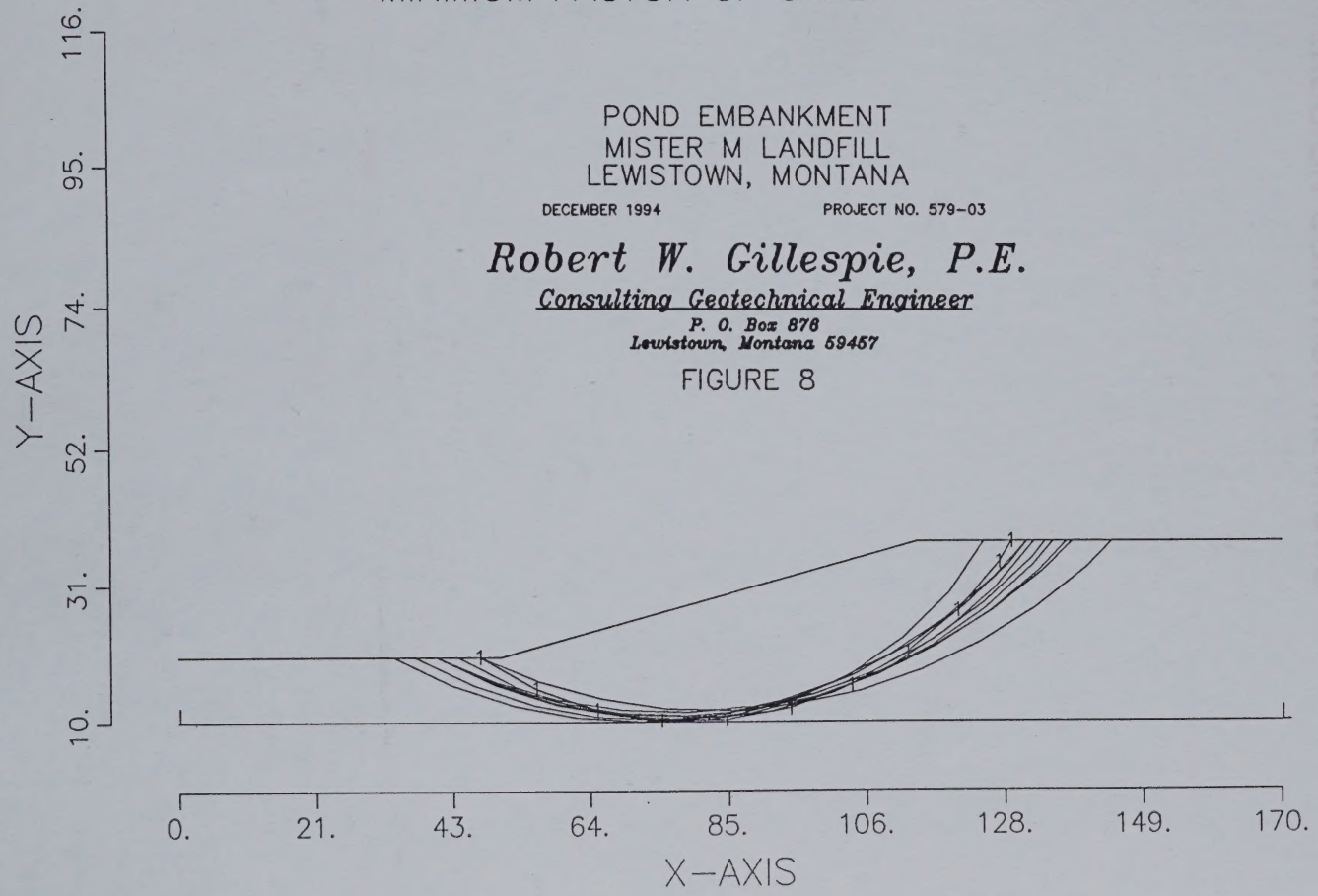
R. W. Gillespie & Assoc.
Sanford, ME (sn 5112)

MISTER M. LANDFILL POND TRIAL 7 (PHI = 0
, NO WATER, NO SEISMIC)
100SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 3.487



R. W. Gillespie & Assoc.
Sanford, ME (sn 5112)

MISTER M. LANDFILL POND TRIAL 8 (PHI = 0
, NO WATER, SEISMIC)
100SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 2.936



POND EMBANKMENT
MISTER M LANDFILL
LEWISTOWN, MONTANA

DECEMBER 1994 PROJECT NO. 579-03

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Consulting Geotechnical Engineer

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FIGURE 8

APPENDIX F

EROSION CONTROL METHODS

FILTER FENCE

Symbol: —x—x—x—x—

Definition:

A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. There are two types. The Silt Fence is a temporary linear filter barrier constructed of synthetic filter fabric, posts and, depending upon the strength of the fabric used, wire fence for support. The Filter Barrier is constructed of stakes and synthetic filter fabric.

Purpose:

1. To intercept and detain small amounts of sediment from disturbed areas during construction operations in order to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes, sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Filter fences must be provided just upstream of the point(s) of discharge of runoff from a site, before the flow becomes concentrated. They may also be required:

  1. Below disturbed areas where runoff may occur in the form of sheet and rill erosion; wherever runoff has the potential to impact downstream resources.

  2. Perpendicular to minor swales or ditch lines for up to one acre contributing drainage areas (in special cases).

- Filter fences should not be constructed in streams or large drainage channels.

- Synthetic fabric filter fences are applicable to only sheet or overland flows and cannot filter the volumes of water in concentrated flows.

Advantages

1. Downstream riparian properties will not be damaged by sediment deposits originating from the

development.

2. Sediment will not cause damage to fish habitat.

Disadvantages/Problems

1. Filter fences are not practical where large flows of water are involved, hence the need to restrict their use to drainage areas of one acre or less and flow rates of less than 0.5 dfs and only used for special circumstances.

2. Problems may arise from incorrect selection of pore size and/or improper installation.

Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council has shown that silt fences can trap a much high percentage of suspended sediments than can straw bales. Silt fences are preferable to straw barriers in many cases. However, while the failure rate of silt fences is lower than that of straw barriers, there are many instances locally in which silt fences have been improperly installed. The installation methods outlined here can improve performance.

Design Criteria

- Drainage area of 1 acre or less or in combination with sediment basin in a larger site.

- Maximum slope steepness (normal (perpendicular) to fence line) 1:1.

- Maximum sheet or overland flow path length to the fence 100 feet.

- No concentrated flows greater than 0.5 cfs.

- Selection of a filter fabric is based on soil conditions at the construction site (which affect the equivalent opening size (EOS) fabric specification) and characteristics of the support fence (which affect the choice of tensile strength). The designer shall specify a filter fabric that retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging. The following criteria is recommended for selection of the equivalent opening size:

  1. If 50 percent or less of the soil, by weight, will pass the U.S. standard sieve No. 200, select the EOS to retain 85 percent of the soil. The EOS should not be finer than EOS 70.

  2. For all other soil types, the EOS should be no larger than the openings in the U.S. Standard Sieve No. 70 [0.0083 in. (0.21 mm)] except where direct discharge to a stream, lake or wetland will occur, then the EOS shall be no larger than Standard Sieve No. 100.

To reduce the chance of clogging, it is preferable to specify a fabric with openings as large as allowed by the criteria. No fabric should be specified with an EOS smaller than U.S. Standard Sieve No. 100 [0.0059 in. (0.14 mm)]. If 85 percent or more of a soil, by weight, passes through the openings in a No. 200 sieve [0.0029 in (0.074 mm)], filter fabric shall not be used. Most of the particles in such a soil would not be retained if the EOS was too large, and they would clog the fabric quickly if the EOS was small enough to capture the soil.

Selection of fabric tensile strength and bursting strength characteristics shall be supported with wire mesh in and as recommended by the fabric manufacturer. Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum os six months of expected usable construction life at a temperature range of 0°F to 120°F.

Standard Notes

In addition to the Technical Information Report required by the local government when preparing an erosion and sediment control plan, add the following notes to the Filter Fabric Fence Detail:

1. The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6 inch overlap, and both ends securely fastened to the post.

2. Posts shall be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 30 inches (where physically possible).

3. A trench shall be excavated approximately 8 inches wide and 12 inches deep along the line of posts and upslope from the barrier. The trench shall be constructed to follow the contour.

4. When standard strength filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 4 inches and shall not extend more than 36 inches above the original ground surface.

5. The standard strength filter fabric shall be stapled or wired to the fence and 20 inches of the fabric shall extend into the trench. The fabric shall not extend more than 36 inches above the original ground surface. Filter fabric shall not be stapled to existing trees.

6. When extra-strength filter fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case, the filter fabric is stapled or wired directly to the posts with all other provisions of Standard Note "e" applying.

7. The trench shall be backfilled with 1/4 inch minimum diameter washed gravel. Local governments may instead specify the use of properly compacted native material.

8. Filter fabric fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

Maintenance

- Inspect immediately after each rainfall and at least daily during prolonged rainfall. Repair as necessary.

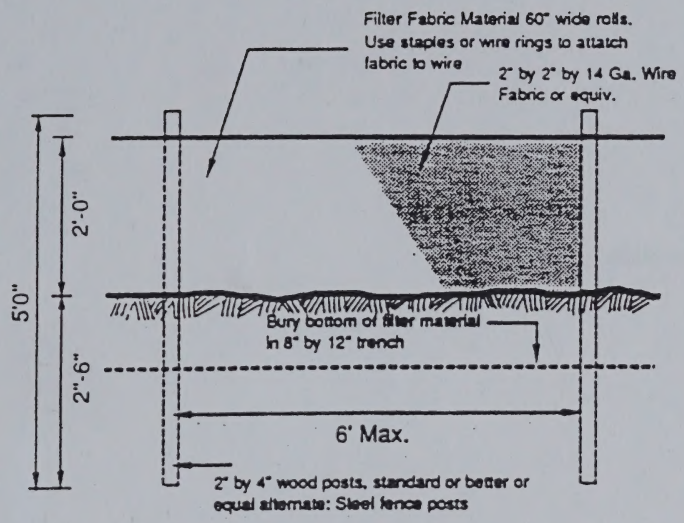
- Sediment must be removed when it reaches approximately one third the height of the fence, especially if heavy rains are expected.

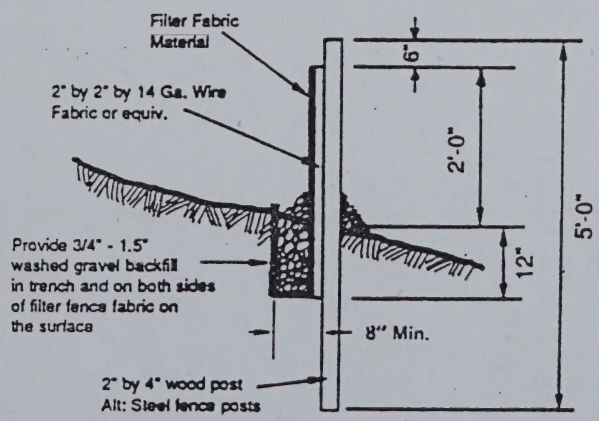
- Any sediment deposits remaining in place after the filter fence is no longer required shall be dressed to conform with the existing grade, prepared and seeded.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed with 30 days after final site stabilization is achieved or after the temporary BMPs are no

longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 13 Filter Fabric Fence Detail





MULCHING AND MATTING

Symbol: ←(MU)→

Definition:

Application of plant residues or other suitable materials to the soil surface.

Purpose:

To provide immediate protection to exposed soils during the period of short construction delays or over winter months through the application of plant residues, or other suitable materials, to exposed soil areas.

Mulches also enhance plant establishment by conserving moisture and moderating soil temperatures. Mulch helps hold fertilizer, seeds and topsoil in place in the presence of wind, rain, and runoff and maintains moisture near the soil surface.

This BMP may be used either alone or in conjunction with other BMPs such as temporary seeding.

Conditions Where Practice Applies

- In areas which have been seeded either for temporary or permanent cover, mulching should immediately follow seeding.
- Areas which cannot be seeded because of the season or are otherwise unfavorable for plant growth.
- Areas which have been seeded as specified in Temporary Seeding (BMP).
- In an area of greater than 2:1 slope, mulching should immediately follow seeding.

Advantages

1. Mulching offers instant protection to exposed areas.
2. Mulches conserve moisture and reduce the need for irrigation.

Disadvantages/Problems

1. Care must be taken to apply mulch at the specified thickness and on steep slopes mulch must be supplemented with netting.
2. Thick mulches can reduce the soil temperature, delaying seed germination.

Planning Considerations

Mulches are applied to the soil surface to conserve a desirable soil property or to promote plant growth. A surface mulch is one of the most effective means of controlling runoff and erosion on disturbed land.

Mulches can increase the infiltration rate of the soil, reduce soil moisture loss by evaporation, prevent

crusting and sealing of the soil surface, modify soil temperatures and provide a suitable microclimate for seed germination.

Organic mulch materials, such as straw, wood chips, bark, and wood fiber have been found to be most effective, although straw is preferred.

A variety of nets and mats have been developed for erosion control in recent years and these are also used as mulches, particularly in critical areas such as waterways. They may be used to hold other mulches to the soil surface.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season and economics. It is especially important to mulch liberally in mid-summer and prior to winter and on cut slopes and southern slope exposures.

Organic Mulches

Straw - Straw is the mulch most commonly used in conjunction with seeding. Its use is recommended where immediate protection is desired and preferably where the need for protection will be less than 3 months. The straw should come from wheat or oats and may be spread by hand or machine. Straw can be windblown and must be anchored down. Common anchoring methods are:

1. Crimping, disking, rolling or punching into the soil;
2. Covering with netting;
3. Spraying with a chemical or fiber binder (tackifier); and
4. Keeping moist. Natural precipitation can often provide sufficient moisture.

Corn Stalks - These should be shredded into 4 to 6-inch lengths. Stalks decompose slowly and are resistant to windblow.

Wood Chips - Suitable for areas that will not be closely mowed and around ornamental plantings. Chips decompose slowly and do not require tacking. They must be treated with 12 pounds nitrogen per ton to prevent nutrient deficiency in plants. Chips can be a very inexpensive mulch if they are obtained from trees cleared on the site. However, both wood and bark chips tend to wash down slopes of more than 6 percent and create problems by clogging inlet grates, etc. and are therefore not preferred for use in those areas.

Bark Chips, Shredded Bark - By-products of timber processing. Used in landscaped plantings. Bark is also a suitable mulch for areas planted to grasses and not closely mowed; may be applied by hand or mechanically. Bark is not usually toxic to grasses or legumes and additional nitrogen fertilizer is not required.

Wood Fiber - Used in hydro-seeding operations, applied as part of the slurry. These short cellulose fibers do not require tacking although a tacking agent or soil binders are sometimes used with wood fiber. This form of mulch does not provide sufficient protection to erodible soils to be used alone during the severe heat of summer or for late fall seedings. Wood fiber hydro-seed slurries may be used to tack straw mulch. This combination treatment is well suited for steep slopes and critical areas and severe climate conditions.

There are other organic materials which make excellent mulches but are only available locally or seasonally. Creative use of these materials can reduce costs.

Chemical Mulches and Soil Binders - The use of synthetic, spray-on materials (except tacking agents used with hydro-seeding) is not recommended. A major problem with their use is the creation of impervious surfaces and, possibly, adverse effects on water quality. Contact the Water Quality Bureau prior to applying these materials.

Nets and Mats - Used alone, netting does not retain soil moisture or modify soil temperature. It stabilizes the soil surface while grasses are being established and is useful in grassed waterways and on slopes. Light netting may also be used to hold other mulches in place. Its relatively high cost makes it most suitable for small sites.

The most critical aspect of installing nets and mats is obtaining firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion occurs. It is important to use an adequate number of staples and to roll the material after laying it to ensure that the soil is protected.

Design Criteria

- Site Preparation = Same as Temporary Seeding.

- Mulch Materials, Application Rates and Specifications - See Table 1

- Erosion blankets (nets and mats) may be used on level areas, on slopes up to 50 percent and in waterways. Where soil is highly erodible, nets shall only be used in connection with an organic mulch such as straw and wood fiber. Jute nets shall be heavy, uniform cloth woven of single jute yarn, which if 36 to 48 inches wide shall weight an average of 1.2 pounds/linear yard. It must be so applied that it is in complete contact with the soil. If it is not, erosion will occur beneath it. Netting shall be securely anchored up to the soil with No. 11 gauge wire staples at least six inches long, with an overlap of three inches.

- Excelsior blankets are considered protective mulches and may be used alone on erodible soils and during all time of the year.

- See Figure 1 for orientation of netting and matting.

Maintenance

- Mulched areas should be checked periodically, especially following severe storms, when damaged areas of mulch or tie-down material should be repaired.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

There are other organic materials which make a excellent mulching but are only available locally or seasonally. Certain use of these materials can be indicated below.

Chemical Mulches and Soil Binders - The use of synthetic, artificial or chemicals to control the growth of weed with hydro-seeding is not recommended. A mulch system with they use is a combination of protective surfaces and, usually, some attention on water-ways. Contact the Water Quality Section prior to applying these materials.

Jutes and Mats - Used alone, netting does not retard soil movement or moisture loss. It stabilizes the soil surface with growing are being established but is useless in stopping wind and water erosion. Light netting may also be used to hold other mulches on place. Its use is high cost, so it is most suitable for small areas.

The most critical aspect of mulching nets and mats is attaining good contact between the material and the soil. Without such contact, the material is useless as erosion control. The operation is to use an adequate number of staples and to hold the material after laying it to keep it from the soil surface.

Selection Criteria

- Site Preparation - Same as for hydro-seeding.
- Mulch Materials, Application Rates and Specifications - See Table 1.
- Erosion blankets mats and mulch may be used on level areas, on slopes up to 50 percent and in waterways. Where soil is highly erodible, mats, with the aid of mulch, provide a organic mulch such as straw and wood fibre. Jute mats are a very inexpensive, lightweight single jute yarn, which is 90 to 93 percent solid and weighs an average of 2.4 pounds/square yard. It must be so anchored that it is in intimate contact with the soil. It is 18 to 20 weeks before occur because it. Netting and mats be securely anchored up to the soil with no. 11 gauge wire staples at least six inches long with an overlap of three inches.
- Excelsior blankets are constructed of interlocking mulches and may be used where on erodible slope and during all time of the year.
- See Figure 1 for orientation of netting and matting.

Maintenance

- Mulched areas should be checked periodically, especially following severe storms. Areas damaged area of mulch or re-seeding should be repaired.

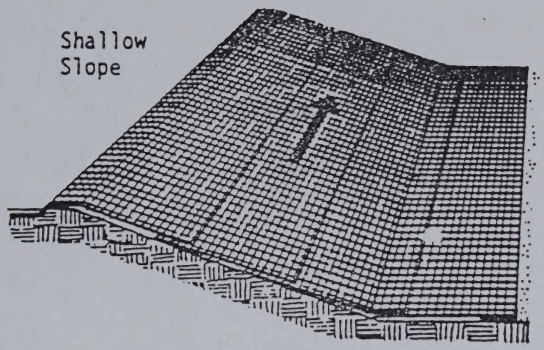
Removal of temporary measures. As temporary erosion and sediment control measures also be removed within 30 days after final site stabilization is completed or after the temporary control are no longer needed. Temporal sediment shall be removed or stabilized on site. Disturbed areas resulting from removal shall be permanently stabilized.

TABLE 1 GUIDE TO MULCH MATERIALS, RATES AND USES

Mulch Material	Quality Standards	Application Rates		Depth of Application	Remarks[1]
		/1000 ft^2	/acre		
Gravel, slag or crushed stone	Washed, 1/4 - 1 1/2 size	9 $yards^3$		3 inches	Excellent mulch for short slopes and around woody plants and ornamentals. Use where subject to foot traffic. Approximately 2000 $lbs/yard^3$
Hay or straw	Air dried, free from unwanted seeds and coarse material	75-100 lbs. or 2-3 bales	1 1/2 - 2 1/2 tons or 90-120 bales	Minimum of 2 inches	Use where the mulching effect is to be maintained for >3 months. Is subject to wind blowing unless kept moist or tacked down. Most common and widely used mulching material. Can be used in critical erosion areas.
Wood fiber cellulose (partially digested wood fibers)	Dyed green should not contain growth inhibiting factors	25-30 lbs.	1000-1500 lbs.		If used on critical areas, double the normal application rate. Apply with hydromulcher. No tie-down required. Packaged in 100 lb. bags.

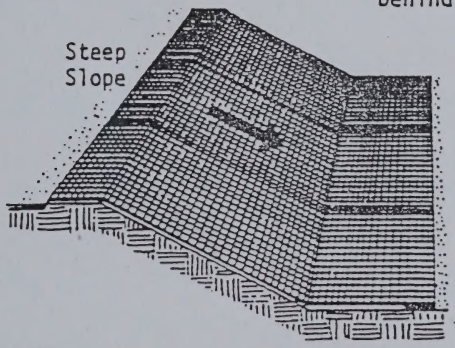
[1] All mulches will provide some degree of (1) erosion control, (2) moisture conservation, (3) weed control, and (4) reduction of soil crusting.

Figure 1 Orientation of Netting and Matting



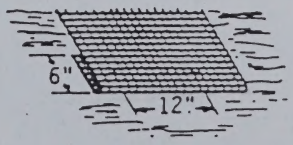
On shallow slopes, strips of netting may be applied across the slope.
(Slopes up to 1:1)

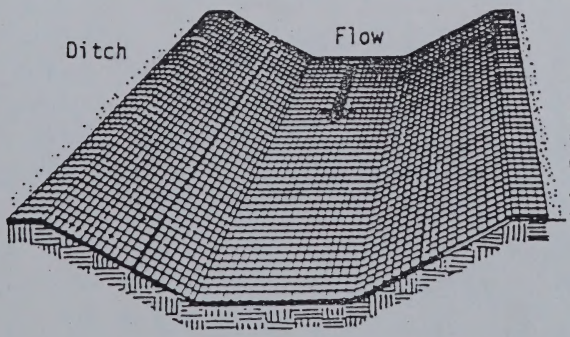
Where there is a berm at the top of the slope, bring the netting over the berm and anchor it behind the berm.



On steep slopes, apply strips of netting parallel to the direction of flow and anchor securely.
(Slopes greater than 1:1)

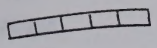
Bring netting down to a level area before terminating the installation. Turn the end under 6" and staple at 12" intervals.





In ditches, apply netting parallel to the direction of flow. Use check slots every 15 feet. Do not join strips in the center of the ditch.

STRAW BALE BARRIER

Symbol: 

Definition:

A temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

Purpose:

1. To intercept and detain small amounts of sediment from disturbed areas of limited extent to prevent sediment from leaving the site.

2. To decrease the velocity of sheet flows and low-to-moderate level channel flows.

Protection of adjacent properties. Properties adjacent to the project site shall be protected from sediment deposition.

Timing and stabilization of sediment trapping measures. Sediment ponds and traps, perimeter dikes, sediment barriers, and other BMPs intended to trap sediment on-site must be constructed as a first step in grading. These BMPs must be functional before land disturbing activities take place. Earthen structures such as dams, dikes and diversions shall be seeded and mulched.

Controlling off-site erosion. Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity and peak flow rate of stormwater runoff from the project site. While conducting land disturbing activities, limit the peak rate of runoff for the 2-year, 24-hour storm to 50 percent of the release rate for existing site conditions.

Conditions Where Practice Applies

- Below disturbed areas subject to sheet and rill erosion.
- Where the size of the drainage area is no greater than 1/4 acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet' and the maximum slope gradient behind the barrier is 50 percent (2:1).
- In minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres.
- Where effectiveness is required for less than 3 months.
- Under no circumstances should straw bale barriers be constructed in live streams, swales or drainages.

Advantages

1. When properly used, straw bale barriers are an inexpensive method of sediment control.

Disadvantages/Problems

1. Straw bale barriers are easy to misuse and can become contributors to a sediment problem instead of a solution.

2. It is difficult to tell if bales are securely seated and snug against each other.

Planning Considerations

Based on observations made locally and in Virginia, Pennsylvania, Maryland and other parts of the nation, straw bale barriers have not been as effective as many users had hoped they would be. There are three major reasons for such ineffectiveness.

1. *Improper use of straw bale barriers has been a major problem. Straw bale barriers have been used in streams and drainageways where high water velocities and volumes have destroyed or impaired their effectiveness.*

2. *Improper placement and installation of the barriers, such as staking the bales directly to the ground with no soil seal or entrenchment, has allowed undercutting and end flow. This has resulted in additions to rather than removal of sediment from runoff waters.*

3. *Inadequate maintenance lowers the effectiveness of these barriers. For example, trapping efficiencies of carefully installed straw bale barriers on one project in Virginia dropped from 57 percent to 16 percent in one month due to lack of maintenance.*

There are serious questions about the continued use of straw bale barriers as they are presently installed and maintained. Averaging approximately $4.00 per linear foot, the thousands of straw bale barriers used annually represent sufficient expense that optimum installation procedures should be emphasized. If such procedures are carefully followed, straw bale barriers can be quite effective. Therefore, continued designation of straw bale barriers as a BMP will be contingent upon significant improvement in the installation and maintenance procedures applied to their use.

Design Criteria

- A formal design is not required.

- Sheet Flow Applications

  1. Bales shall be placed in a single row, lengthwise on the contour, with ends of adjacent bales tightly abutting one another.

  2. All bales shall be either wire-bound or string-tied. Straw bales shall be installed so that the bindings are oriented around the sides rather than along the topes and bottoms of the bales in order to prevent deterioration of the bindings.

  3. The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. The trench must be deep enough to remove all grass and other material which might allow underflow. After the bales are staked and chinked (filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier.

  4. Each bale shall be securely anchored by at least 2 stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or re-bars shall be driven deep enough into the ground to securely anchor the bales. Stakes should not extend above the bales but instead

2. It is difficult to tell if bales are secured at top and some problem exists elsewhere.

Possible Causes/Reasons

Based on observations made during the visit to Vipond, Crossfield, Alberta, and other sights of the nation, some bale burning problems have been noted as occurring on many bales and appear now widespread. There are three major reasons for such problems occur:

1. Improper use of twine bale burning has been a very widespread fault. Since the bale burners have been used in farmyards and pastures where bale wrapping was commonly used (twine removed or improperly done).

2. Improper placement and orientation of the bale burner, such as placing the bale burner over the top of the ground with no and soil or concrete pad. This allows the heat to burn through the bale, causing it and stop to rotate (pop or roll).

3. Inadequate motor power causes the auger to stop or slow down. This causes the bale to pop, resulting in inconvenience of cleaning operation and time. Some problems can be prevented by using a motor equivalent to 10 horsepower and in some models plus up to 3/4 of a horsepower.

There are various questions as to the effectiveness of use of straw bale burners as a way of managing straw and manure. Many farmers have used the bale burner for burning straw and manure, but some have found burning straw and manure difficult. Manure burners are also used for burning straw, and the manure. If straw burners are properly followed, straw bale burners can be quite effective. Therefore, continued development of straw bale burners, such as SWI, will be dependent on improvements in the burner design and manufacture, and on the farmers adapting to its use.

Design Criteria

- A formal design is not required.

- Bales Burn Requirements

1. Bales must be placed in a upright position, on a platform or the ground, with angle of angle bales slightly at angling into straw.

2. All bales shall be either twine tied or strap tied. Straw bales shall be tied so that the bindings are arranged around the bale, either along the top or and a number of the bales to allow for ease of removal of the bands.

3. The burner shall be constructed and bolted and. A trench shall be constructed the width of a bale and the length of the burner to a depth of a trench or deep pit. The trench must be deep enough to provide a space and allow a small amount of air underflow. Also the bale burner shall be stabilized and chained down to prevent it from and shall be bolted to the ground. Bales shall be placed in the burner, so that the bales on the downwind side shall be built up to 4 inches higher than the upwind side of the burner.

4. Each bale shall be secured securely by at least 2 straws or twines of twin binding the bale. The twin straw in each bale shall be chosen towards the exterior. Add bale to force the bales together. Stakes or rebar shall be driven down on both sides of the bale to as away anchor the bales. Stakes should not exceed the bales, but instead

should be driven in flush with the tope of the bale for safety reasons.

5. The gaps between the bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency. Wedging must be done carefully in order not to separate the bales.

Cross Section of a Properly Installed Straw Bale Barrier

6. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

7. Straw bale barriers shall be removed when they have served their usefulness, but not before the upslope areas have been permanently stabilized.

- Channel Flow Applications

1. Bales shall be placed in a single row, lengthwise, oriented perpendicular to the contour, with ends of adjacent bales tightly abutting one another.

2. The remaining steps for installing a straw bale barrier for sheet flow applications apply here, with the following addition:

3. The barrier shall be extended to such a length that the bottoms of the end bales are higher in elevation that the top of the lowest middle bales to assure that sediment-laden runoff will flow either through or over the barrier but not around it.

Maintenance

- Straw bale barriers shall be inspected immediately after each runoff-producing rainfall and at least daily during prolonged rainfall.

- Close attention shall be paid to the repair of damaged bales, end runs and undercutting beneath bales.

- Necessary repairs to barriers or replacement of bales shall be accomplished promptly.

- Sediment deposits should be removed after each runoff-producing rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.

- Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.

All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed with 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

should be taken in order with the work of the b. to assure reasons.

8. The pace between the bales must be packed and wedged with straw to prevent water from escaping between the bales. Loose straw attached to the bales unnecessarily upset from a strong bale dampen and fill in spaces inside effectively. Wedging must be done carefully in order not to damage the bales.

Cross Section of a Properly Installed Straw Bale Dyke

6. Inspection shall be made in and repair or replacement shall be made promptly as needed.

7. Straw bale barriers shall be cleaned when they have reached about half capacity, but only before the sediment can reach from downstream by storms.

Construction Sequence

1. Bales shall be placed in a single row, lengthwise, adjacent and tightly butted to a common with ends of adjacent bales tightly wedged together with straw.

2. The remaining area for excavating a straw bale barrier is determined by applying the here, with the following formula.

3. The barrier shall be constructed in such a way that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale to prevent the sediment laden runoff will flow around through or over the barrier rather than through it.

Maintenance

- Straw bale barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall.

- Close attention shall be paid to the repair of damaged bales, and rills and scour holes beneath bales.

- Necessary repairs to barriers or replacement of bales shall be accomplished promptly.

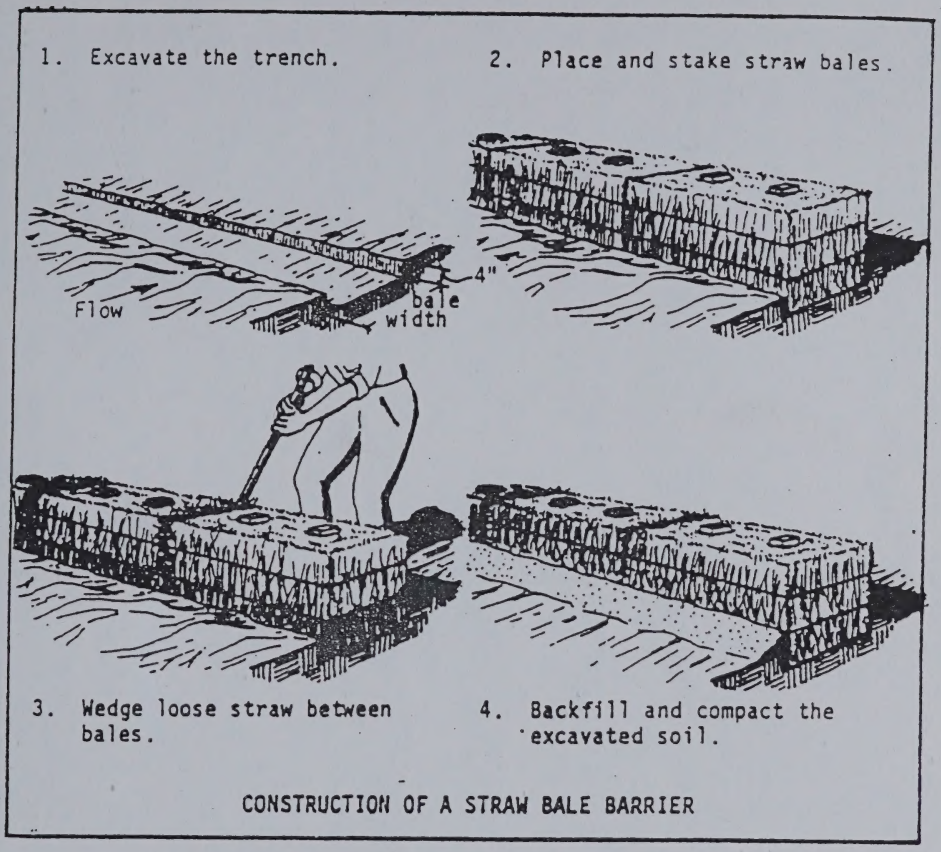
- Sediment deposits should be removed after each rainfall event preceding rainfall. They must be removed when the level of deposition reaches approximately one half the height of the barrier.

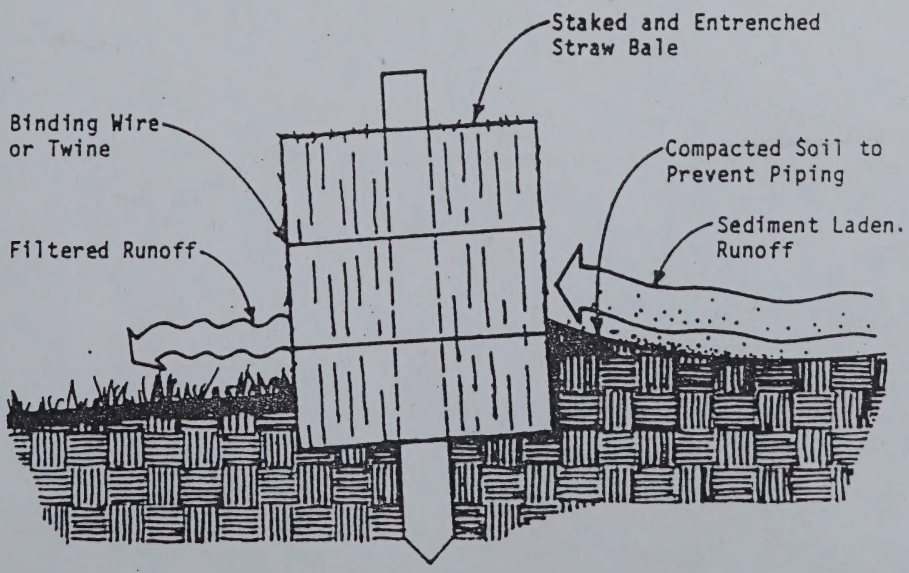
- Any sediment deposits remaining in place after the straw bale barrier is no longer needed shall be directed to conform to the adjacent grade, prepared and stabilized.

All temporary and permanent erosion and sediment control practices must be maintained and repaired as needed to assure continued performance of their intended functions.

Removal of temporary measures. All temporary erosion and sediment control measures shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment must be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

Figure 14 STRAW BALE BARRIER





GRADIENT TERRACES

Symbol:

Definition:

An earth embankment or a ridge-and-channel constructed with suitable spacing and with an acceptable grade.

Purpose:

To reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity. (This standard covers the planning and design of gradient terraces and does not apply to diversions.)

Conditions Where Practice Applies

- Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may be used only where suitable outlets are or will be made available.

Advantages

1. Gradient terraces slow the velocity of runoff, increase the distance of overland flow and reduce effective hydraulic gradient. They also hold moisture and minimize sediment.

Disadvantages/Problems

1. May significantly increase cut and fill costs and cause sloughing if excessive water infiltrates soils.

Design Criteria

- The maximum spacing of gradient terraces should be determined by the following method: V.I. = xs + y

Where:	V.I. =	vertical interval in feet
	x =	0.8
	s =	land slope in feet per 100 feet
	y =	a soil and cover variable with values from 1.0 to 4.0[1]

- The minimum constructed cross-section should meet the design dimensions.

- The top of the constructed ridge should not be lower at any point than the design elevation plus

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[1]Values of "y" are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The high value is applicable only to erosion resistant soils where a large amount of residue (1.5 tons of straw per acre equivalent) is on the surface.

the specified overfill for settlement. The opening at the outlet end of the terrace should have cross section equal to that specified for the terrace channel.

- Channel Grade - Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length. For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is non-erosive for the soil type with the planned treatment.

- All gradient terraces should have adequate outlets. Such an outlet may be a grassed waterway, vegetated area or tile outlet. In all cases, the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover should be used in the outlet channel.

- The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.

Specifications

- Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet (Figure 6).

- The drainage area above the top should not exceed the area that would be drained by a terrace of equal length with normal spacing.

- Capacity - The terrace should have enough capacity to handle the peak runoff expected from a 10-year, 24-hour design storm without overtopping.

- Cross-Section - The terrace cross-section should be proportioned to fit the land slope. The ridge height should include a reasonable settlement factor. The ridge should have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent and 6 square feet for slopes steeper than 8 percent.

Maintenance

- Maintenance should be performed as needed. Terraces should be inspected regularly; at least once a year and after large storm events.

the selected overall for landscaping. The spacing of the outlet are of the terrace should have cross section equal to that specified for the terrace channel.

Channel Grade - Channel grades may be either uniform or variable with a minimum grade of 0.5 feet per 100 feet length. For short channels, a rise greater may be acceptable to improve alignment. The channel velocity should not exceed that at which it operates by the design type with the planned treatment.

All ornamental terrace should have adequate outlets. Such as outlet may be a garden area, a vegetated area or pit outlet. In all cases, the outlet must carry runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover should be used in the outlet channel.

The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet, at their junction, when both are operating at design flow.

Applications

Vertical spacing determined by the above criteria may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better maneuvering or operating, to avoid odd sizes, to adjust for equipment size, or to reach a stable vertical spacing (Figure 6).

The drainage area along the top should not exceed the area that would be drained by a terrace of equal length with normal spacing.

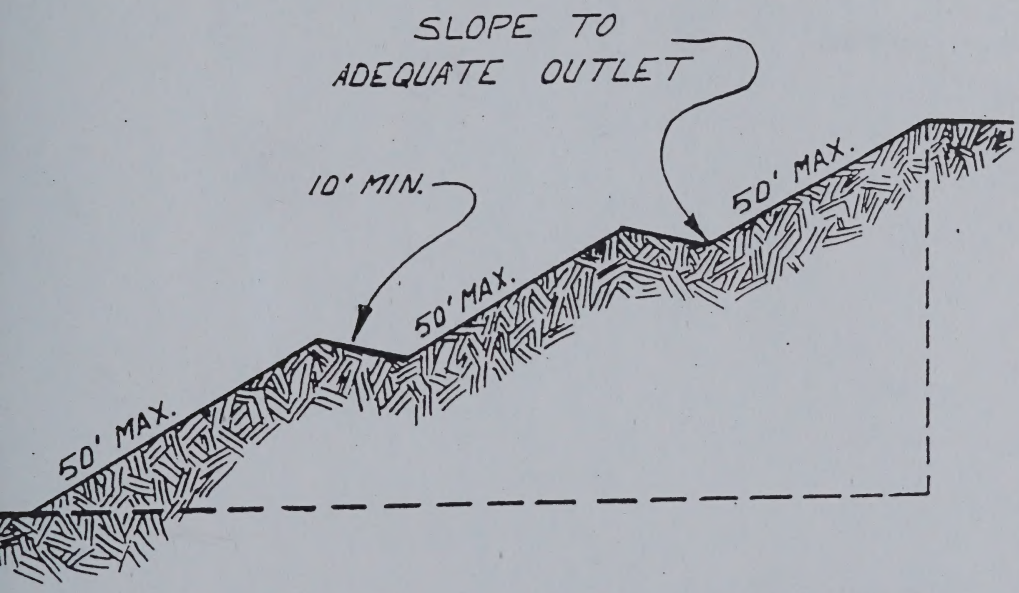
Capacity - The terrace should have enough capacity to handle the peak runoff expected from a 10-year, 24-hour design storm without overtopping.

Cross Section - The terrace cross-section should be proportional to its level grade. The design height should include a reasonable settlement factor. The base should have a minimum of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should be 8 square feet for up to slopes of 3 percent or less, 7 square feet for slopes from 3 to 6 percent and 6 square feet for slopes greater than 6 percent.

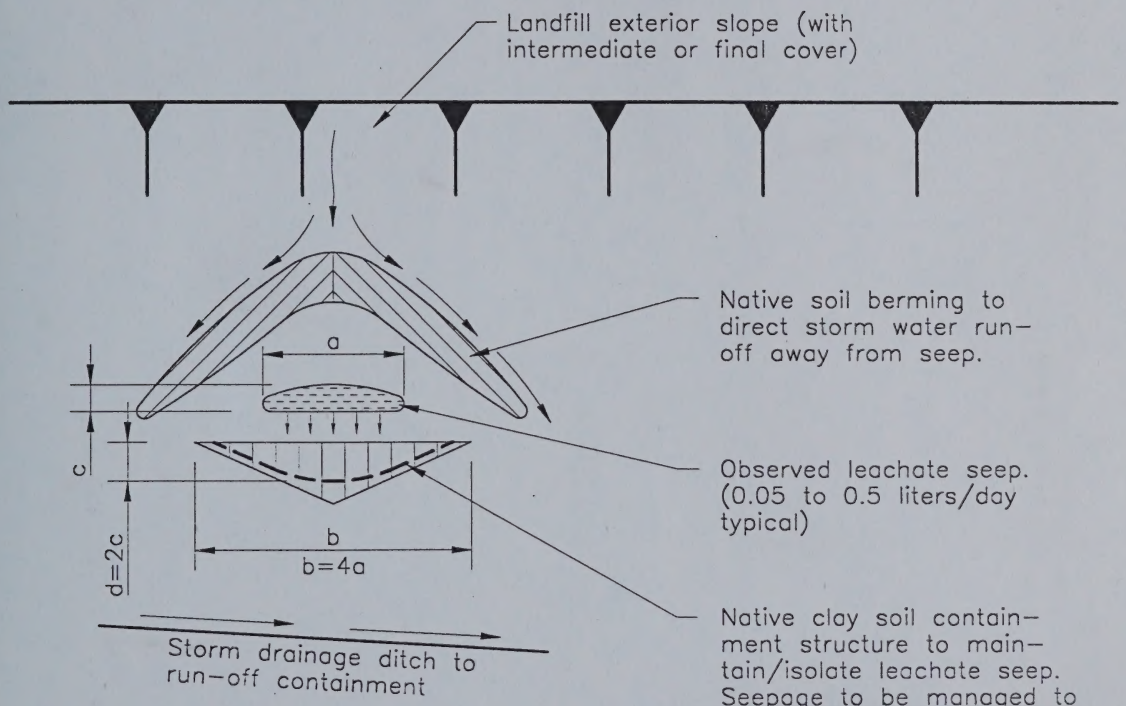
Maintenance

Maintenance should be performed as needed. Terraces should be inspected regularly, at least once a year and after large storm events.

Figure 6 Gradient Terraces



BMP TO PREVENT CONTACT OF STORM WATER WITH SHORT TERM LEACHATE SEEPS



a = Width along slope of seep

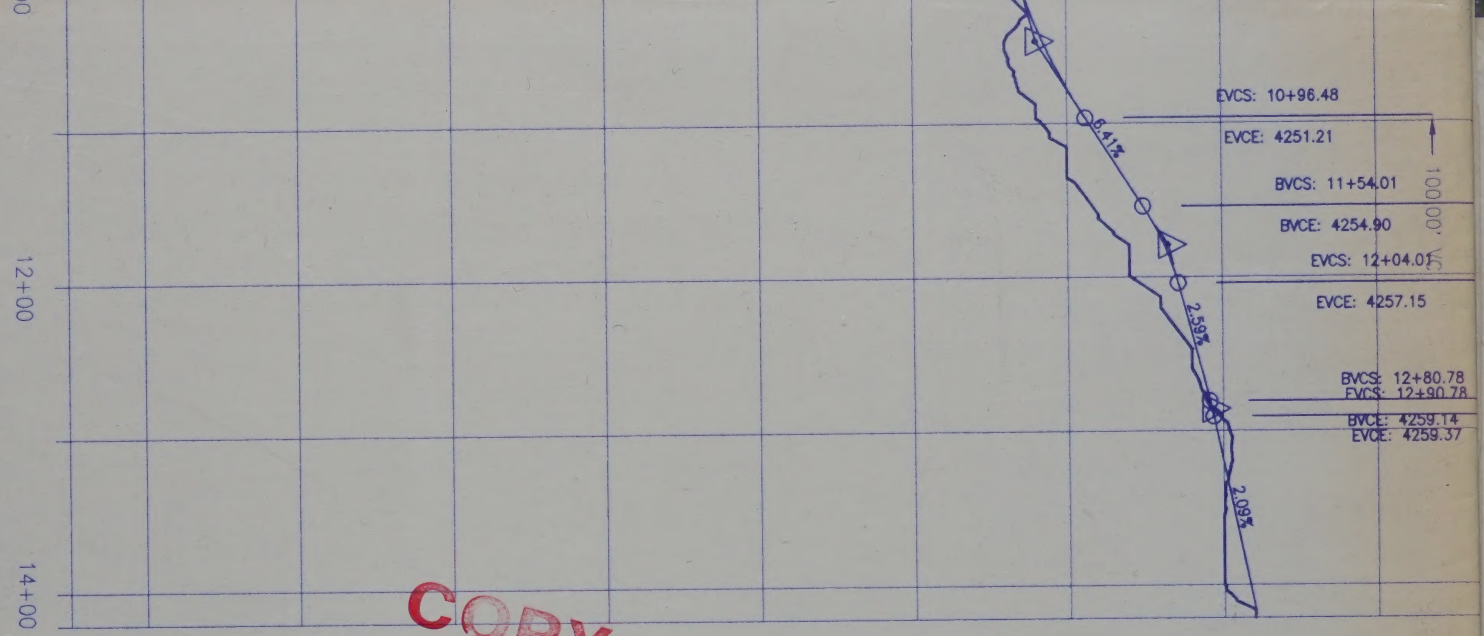
c = Height of exposed face

NOTE:

Should contained leachate accummulate to a depth of .8d in the containment structure the leachate shall be pumped into a sealed and labeled drum for disposal at an approved POTW.

APPENDIX G

DESIGN SHEETS 1 TO 5



COPY

PROJECT NUMBER
2729.002-010-0112

SHEET NUMBER
3

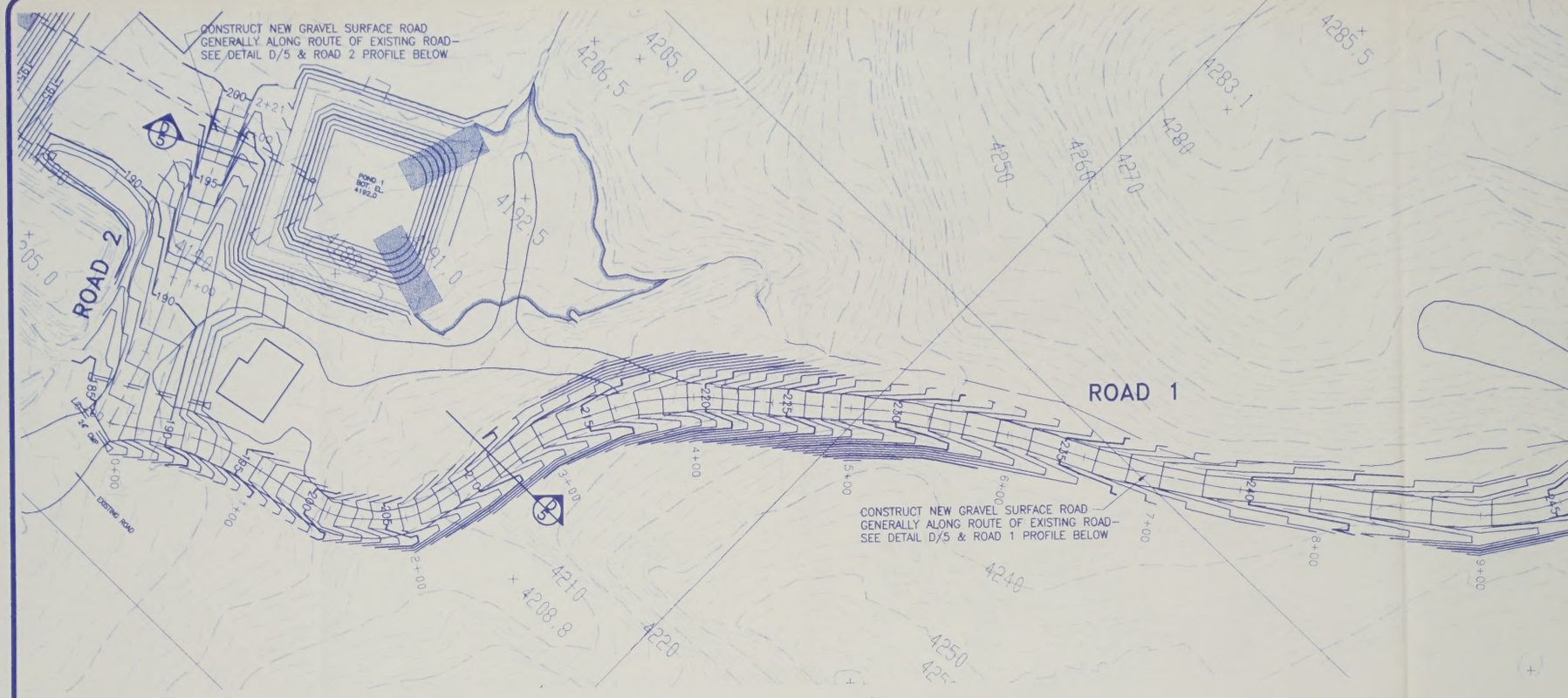
RUN-ON/RUN-OFF CONTROL PLAN
FOR
MISTER M LANDFILL
LEWISTOWN, MONTANA

ROAD 1 & 2 - PLAN AND PROFILE

DRAWN BY: XXX
CHK'D. BY: XXX
APPR. BY: XXX
DATE: X/XX

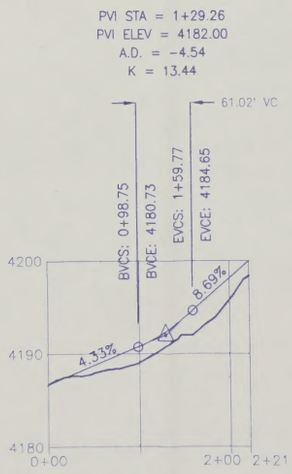
Q. A.
PEER REVIEW XXX

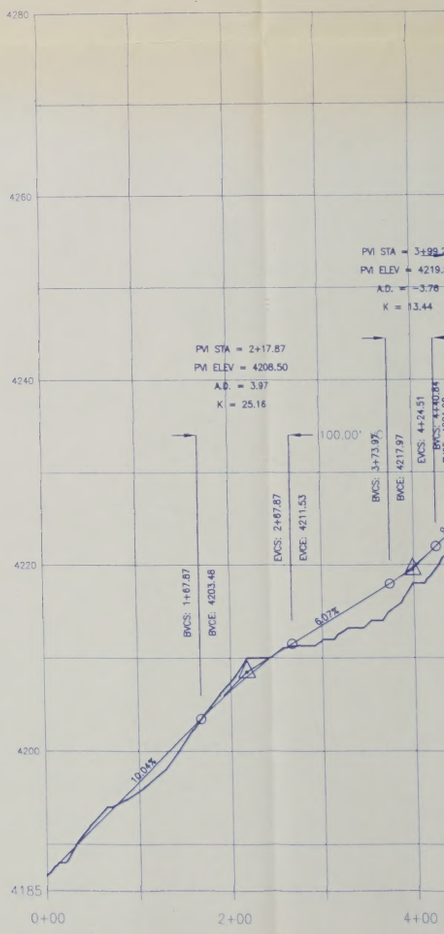
Morrison Maierle/
SINCE 1945



ROAD 1 & 2 PLAN

HOR. SCALE: 1"=50'





ROAD 2 PROFILE

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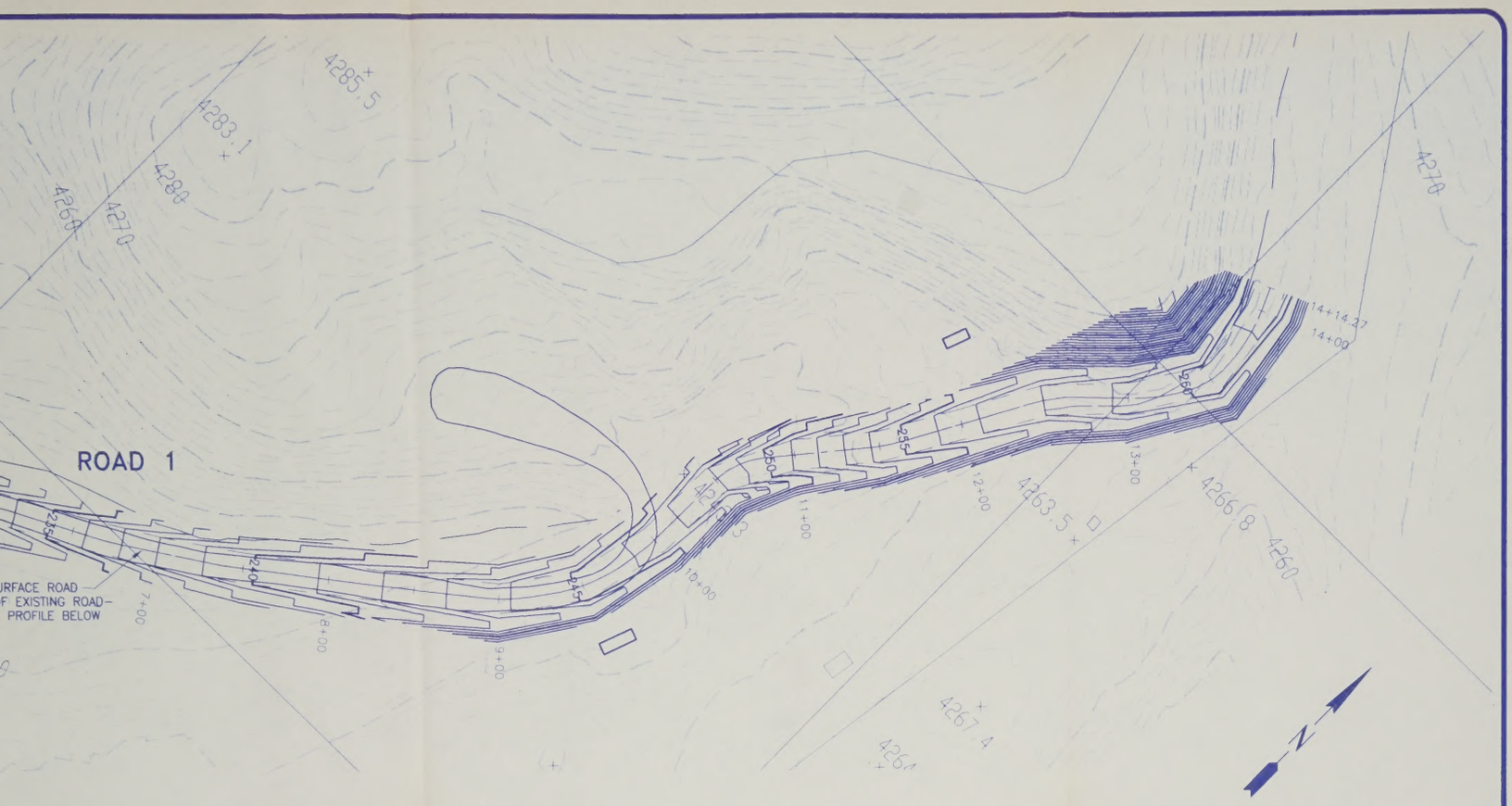

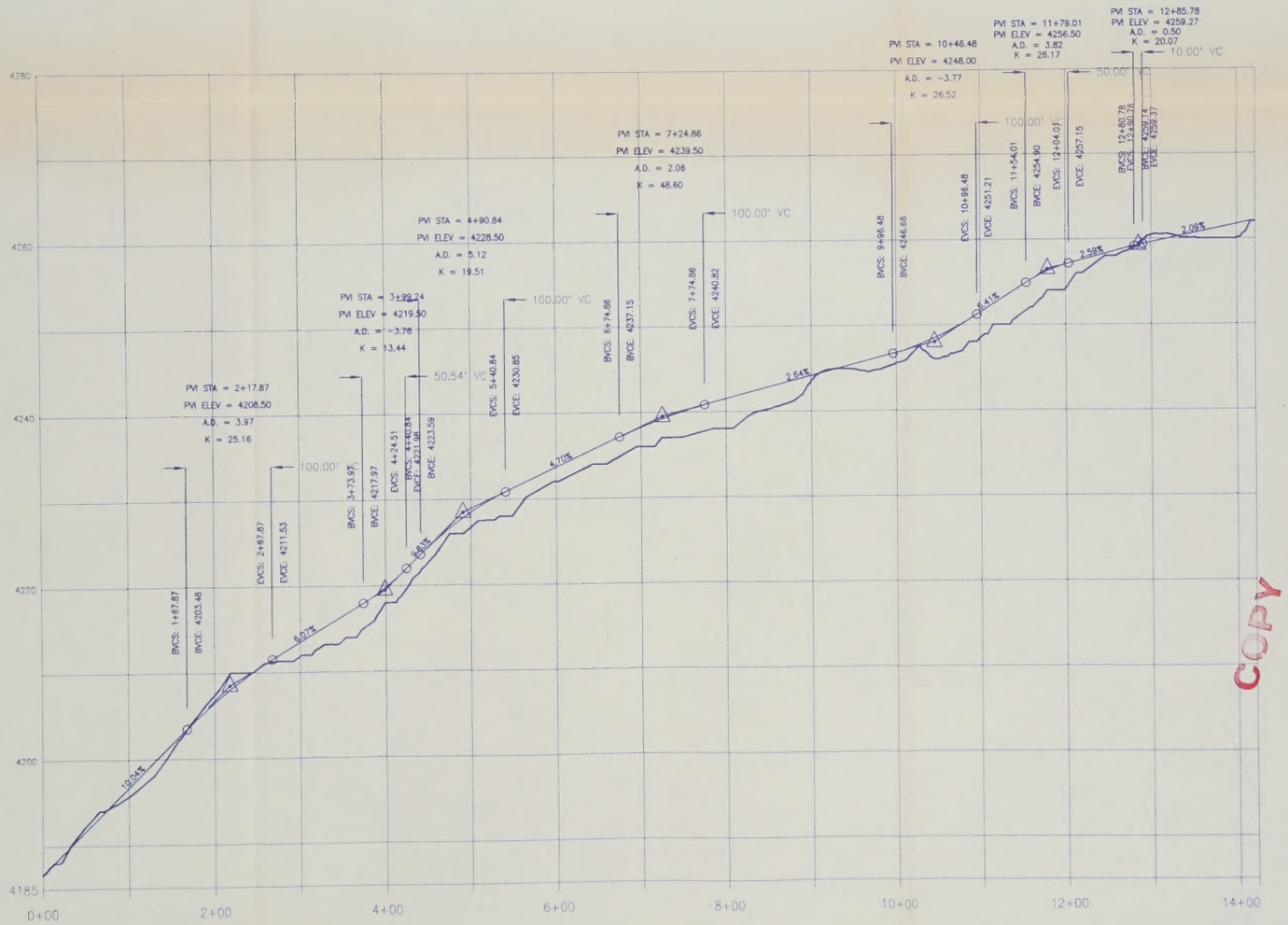

COPY

ROAD 1 PROFILE

HOR. SCALE: 1"=100' VERT. SCALE: 1"=10'

NO.	DESCRIPTION	DATE	BY:

REVISIONS

MONTANA KENNETH W. SALO 7678E REGISTERED PROFESSIONAL ENGINEER

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Morrison/Maierle/CSSA
SINCE 1945

DRAWN BY: XXX
CHK'D. BY: XXX
APPR. BY: XXX
DATE: X/XX

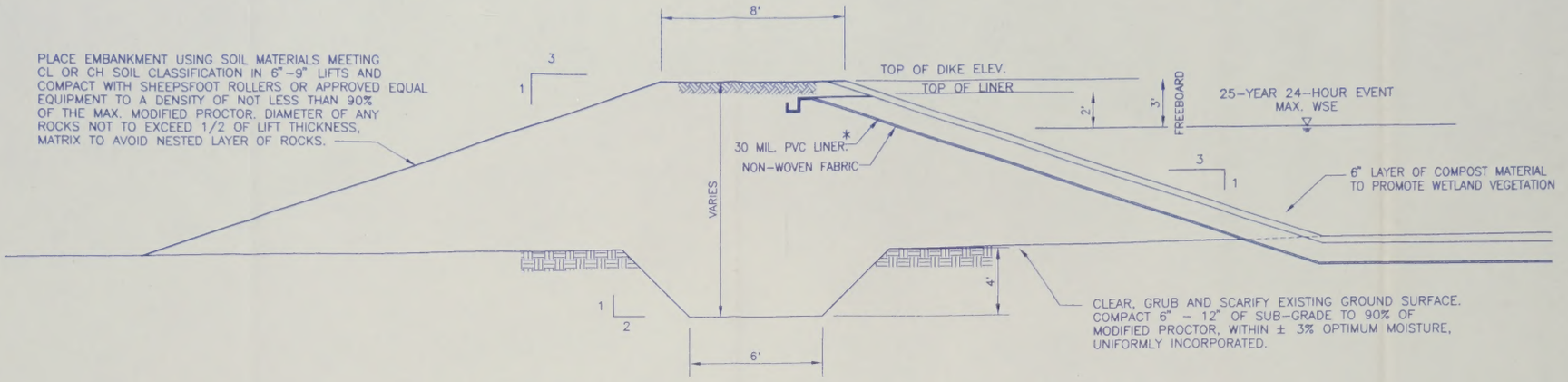
Q. A.
PEER REVIEW XXX

RUN-ON/RUN-OFF CONTROL PLAN
FOR
MISTER M LANDFILL
LEWISTOWN, MONTANA

ROAD 1 & 2 - PLAN AND PROFILE

PROJECT NUMBER
2729.002-010-0112

SHEET NUMBER
3



TYPICAL DIKE CROSS SECTION

A/4

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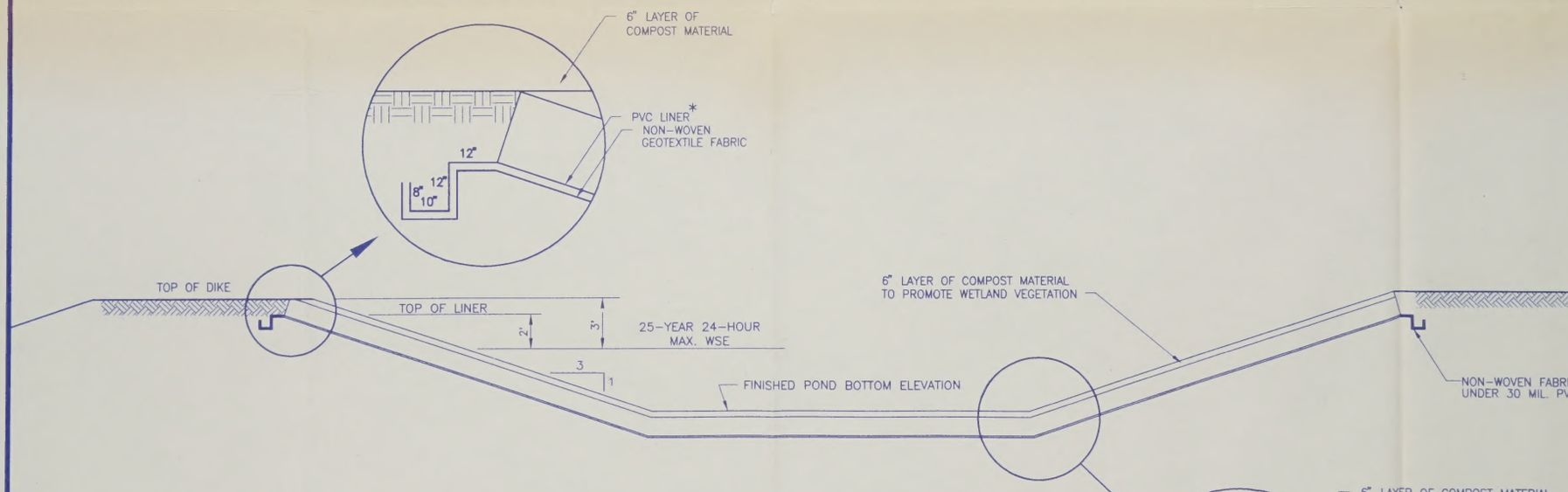
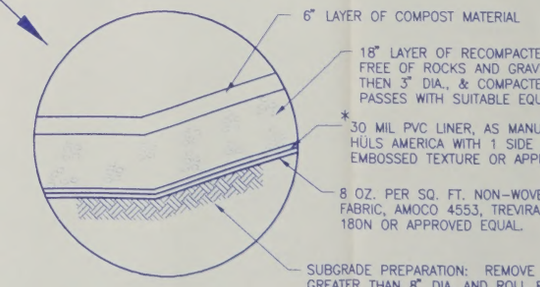
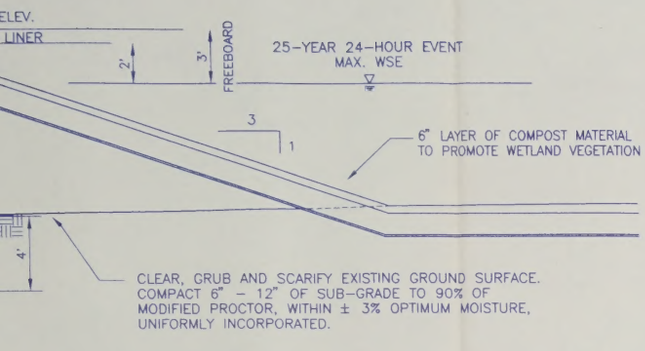


DIKE LINER TYPICAL SECTION

E/4





A
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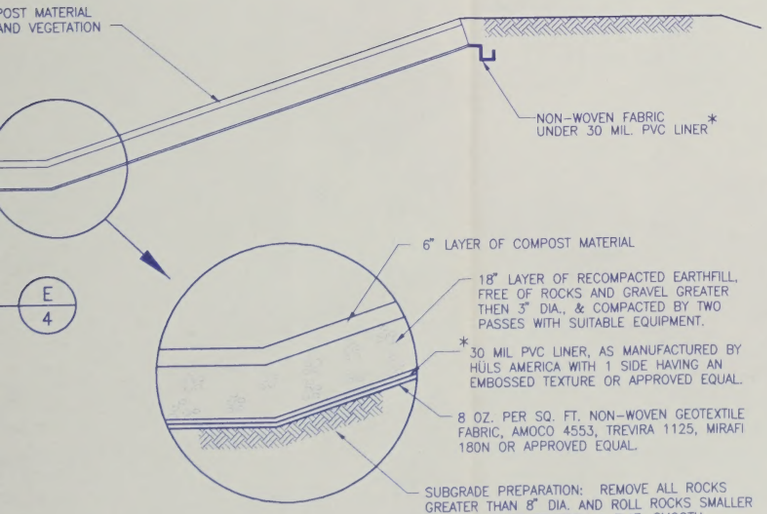

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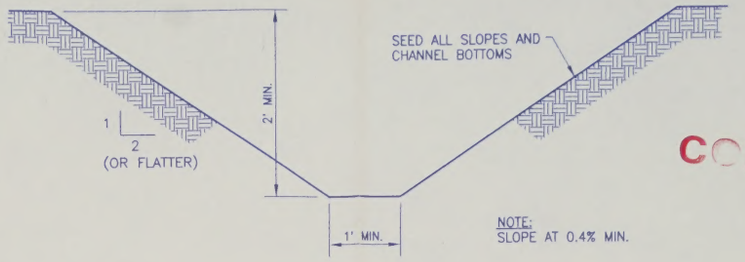

COPY

1 FOOT DITCH CROSS SECTION

C
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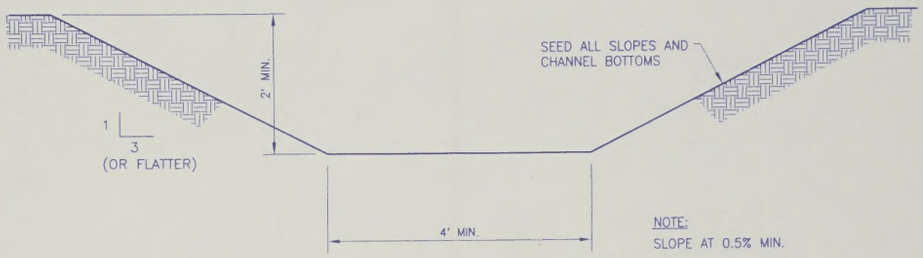

4 FOOT DITCH CROSS SECTION

D
4

NO SCALE

NOTE:

ALL DISTURBED AREAS, INCLUDING THE POND BOTTOM & DRAINAGE DITCHES, SHALL BE SEEDED WITH A SEED MIXTURE PER THE FOLLOWING TABLE:

GRASS MIXTURE	DRILLED lbs/acre	HYDROSEEDING lbs/acre
WESTERN WHEATGRASS	4	8
THICKSPIKE WHEATGRASS	4	8
SLENDER WHEATGRASS	1	2
GREEN NEEDLEGRASS	1	2
TOTAL	10	20

WHERE POSSIBLE, A FIRM WEED FREE SEED BED WOULD BE PREPARED WITH UP TO 4" OF TOPSOIL. A FERTILIZER APPLICATION OF 30 POUNDS OF ACTUAL NITROGEN WOULD BE MADE PRIOR TO SEEDING. DRILLED SEEDING WOULD BE PREFERRED OVER HYDROSEEDING.

DRILLED SEEDING WOULD BE DONE TWICE WITH THE SECOND OPERATION DONE AT AN ANGLE TO THE FIRST OPERATION. THE RECOMMENDED SEEDING RATE WOULD BE MAINTAINED BY SEEDING 1/2 OF THE SEED DURING EACH OPERATION.

HYDROSEEDING WOULD BE RECOMMENDED ON SLOPES TOO STEEP FOR DRILLING OPERATIONS. A MULCH SLURRY WOULD BE APPLIED WITH A TRACER AT A RATE OF 4000 POUNDS PER ACRE. APPROXIMATELY 500 POUNDS PER ACRE WOULD BE APPLIED WITH THE SEEDING MIX AND 3500 POUNDS PER ACRE WOULD BE APPLIED AFTER THE HYDROSEEDING OPERATION.

FERTILIZER WOULD BE APPLIED FOLLOWING THE SEEDING OPERATION AT THE RATE OF 100 POUNDS OF 16-20-0 PER ACRE. A 34-0-0 FERTILIZER APPLICATION WOULD BE APPLIED IN THE YEAR FOLLOWING SEEDING.

THE POND BOTTOM WOULD BE PREPARED FOR THE ESTABLISHMENT OF WETLANDS VEGETATION BY THE FOLLOWING MEANS:

1) FOLLOWING THE PREPARATION OF THE SUB-GRADE, STOCKPILED TOPSOIL AND LANDFILL COMPOST MATERIALS WOULD BE PLACED ON ALL DISTURBED AREAS ASSOCIATED WITH WETLANDS DEVELOPMENT TO A MINIMUM DEPTH OF 6"

2) SEEDING AND PLANTING WOULD THEN FOLLOW.

3) FOLLOWING THE PLACEMENT OF TOPSOIL, SALVAGED AQUATIC SOILS AND VEGETATION, INCLUDING CATTAILS, SEDGES, AND RUSHES WOULD BE SPREAD OVER THE POND BOTTOM AT A RATE OF APPROXIMATELY 10 TO 20 CUBIC YARDS PER ACRE. EXISTING WETLANDS AREAS MUST NOT BE DISTURBED BY THIS OPERATION.

4) ALL TOPSOIL AREAS AND SEEDED AREAS WOULD BE FERTILIZED AT A RATE OF 40 POUNDS OF NITROGEN PER ACRE AND 40 POUNDS OF PHOSPHATE PER ACRE.

5) PERIODIC MONITORING OF THE TYPES OF VEGETATION ESTABLISHED WILL BE REQUIRED TO DETERMINE WHETHER UNDESIRABLE DEEP-ROOTED PLANTS ARE BEING ESTABLISHED THAT WOULD COMPROMISE THE PVC LINER. THESE TYPES OF VEGETATION WOULD BE REMOVED BEFORE THEY BECAME SUBSTANTIAL IN SIZE AND COULD DAMAGE THE LINER. IF A SUBSTANTIAL DEEP-ROOTED PLANT DID BECOME ESTABLISHED, IT WOULD BE REMOVED AND THE LINER INSPECTED IN THAT AREA FOR INTEGRITY.

NO.	DESCRIPTION	DATE	BY:

REVISIONS

MONTANA KENNETH W. SALO 7678E REGISTERED PROFESSIONAL ENGINEER

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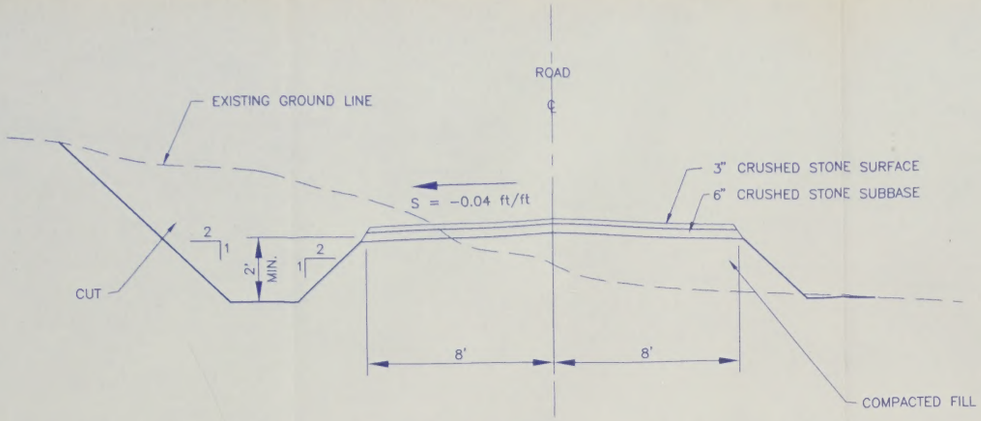
DRAWN BY: JWH
CHK'D. BY: MAF
APPR. BY: KWS
DATE: 1/95
Q. A. PEER REVIEW MAF

RUN-ON/RUN-OFF CONTROL PLAN
FOR
MISTER M LANDFILL
LEWISTOWN, MONTANA

MISCELLANEOUS DETAILS

PROJECT NUMBER
2729.002-010-0112

SHEET NUMBER
4



TYPICAL ROAD SECTION (D/5)

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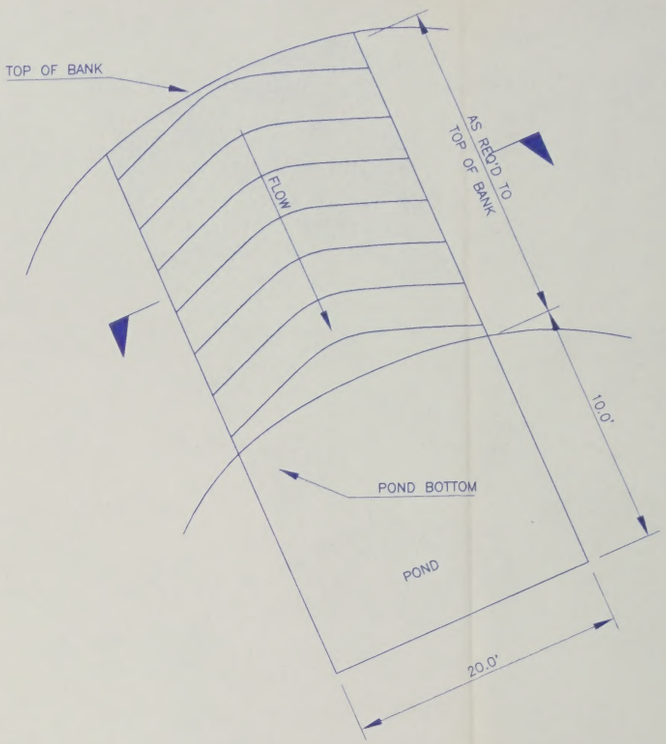
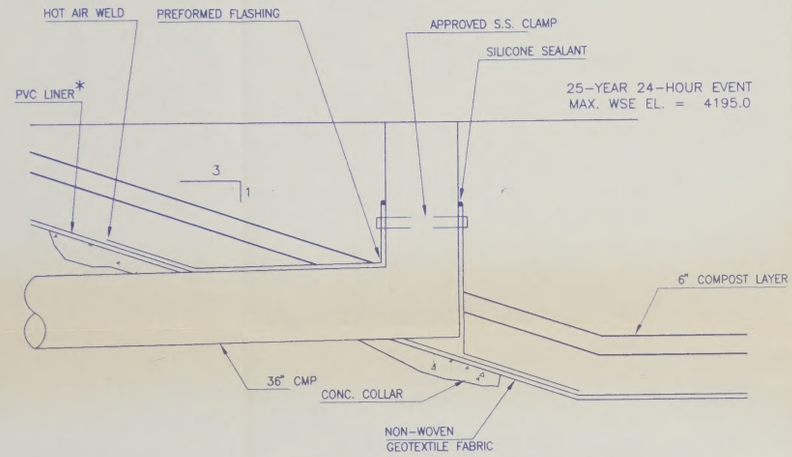


PLAN

GABION DET

NO SCALE



TYPICAL PIPE PUNCTURE SEAL DETAIL (B/5)

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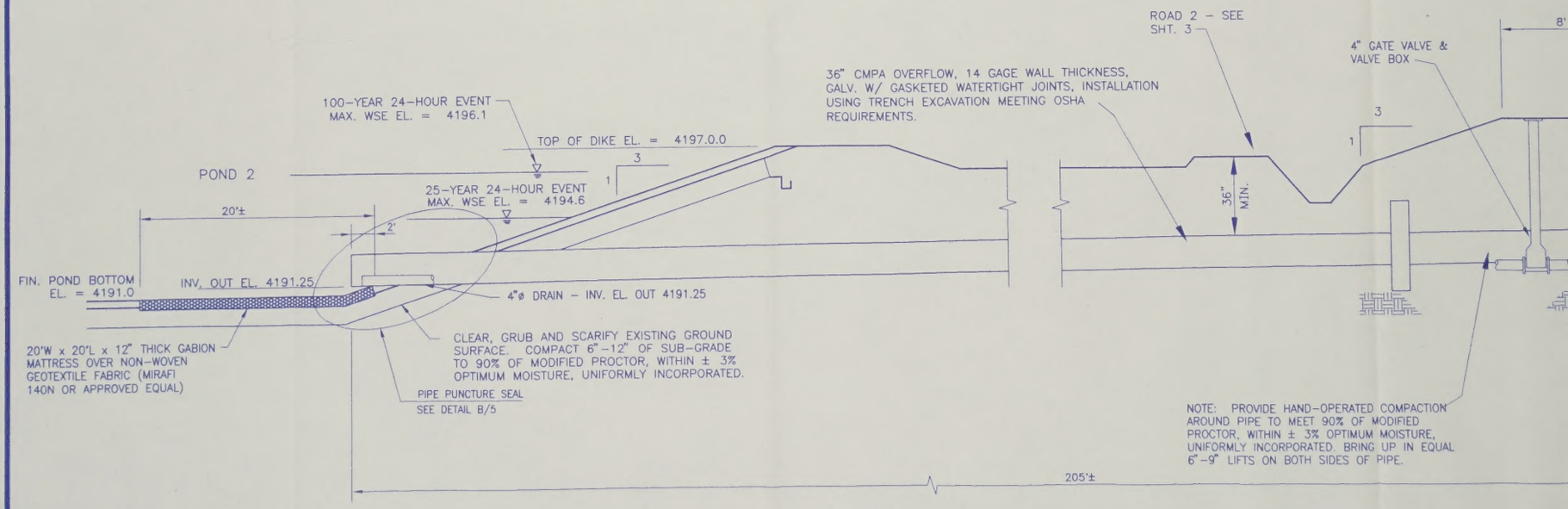

POND 1 & 2 OUTLET SECTION (A/5)

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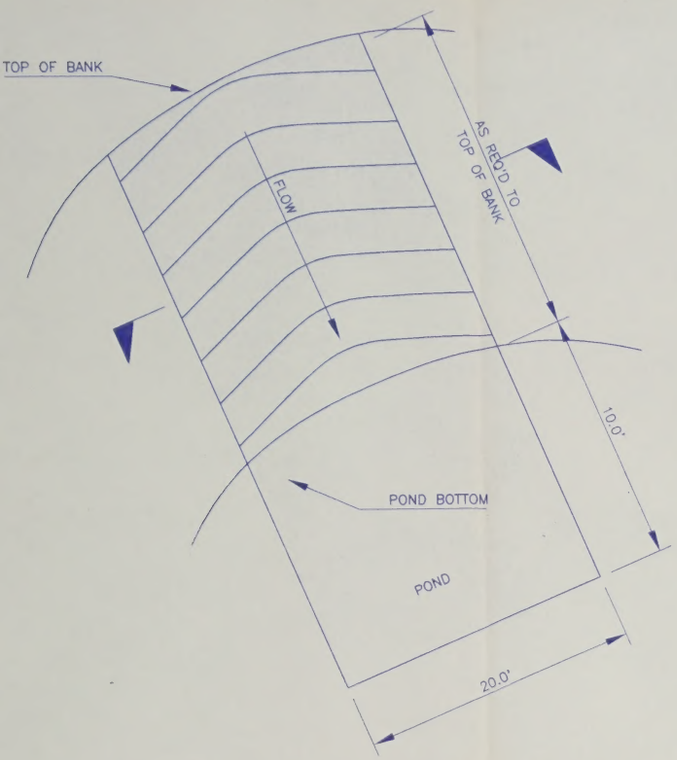
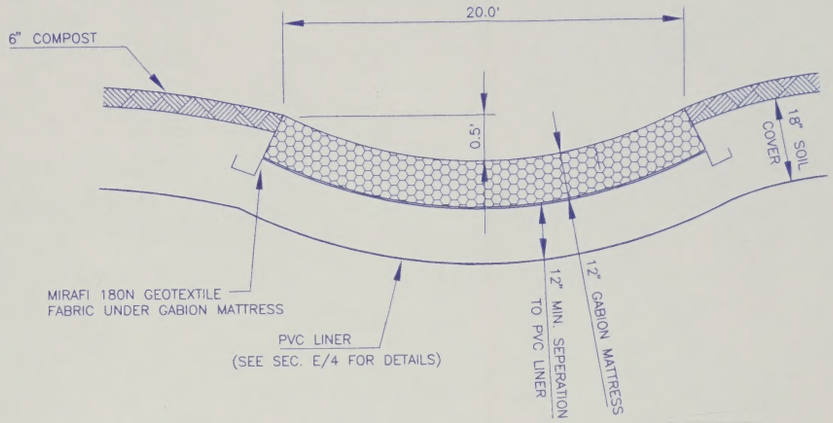


PLAN

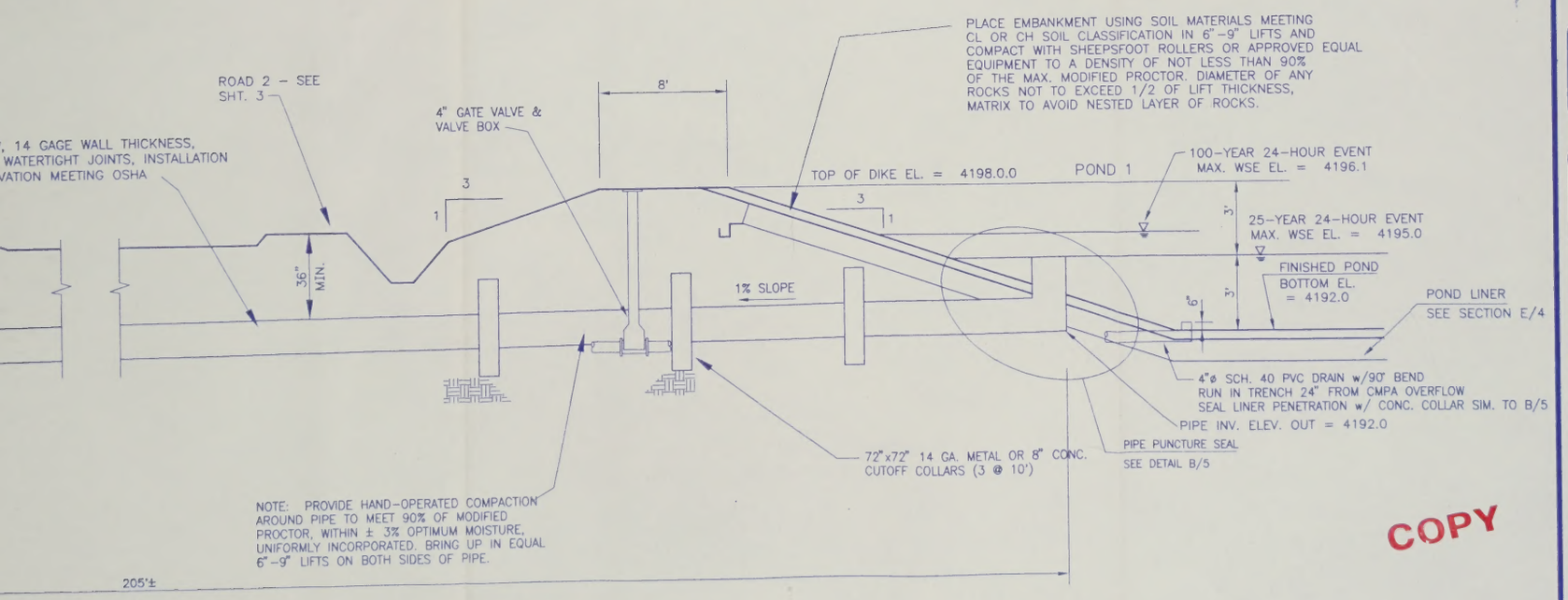


SECTION

GABION DETAIL

NO SCALE

C/5



COPY

POND 1 & 2 OUTLET SECTION

NO SCALE

A/5

NO.	DESCRIPTION	DATE	BY:

REVISIONS

MONTANA KENNETH W. SALO 7678E REGISTERED PROFESSIONAL ENGINEER

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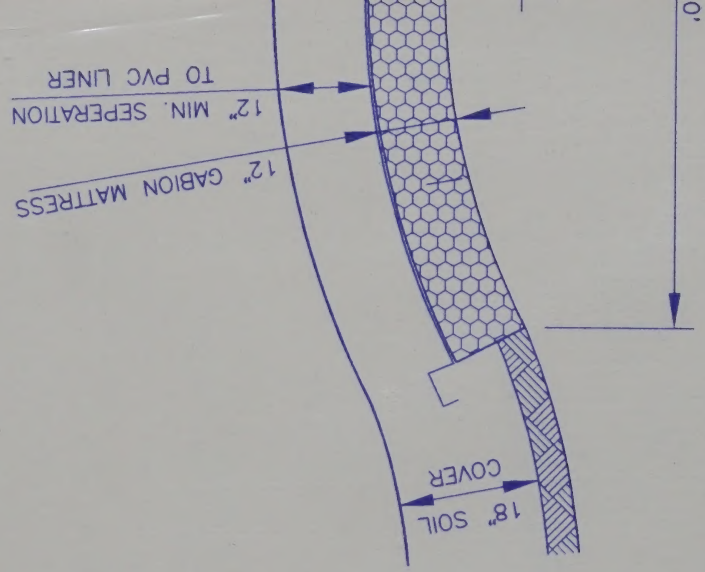
DRAWN BY: JMH
CHK'D BY: MAF
APPR. BY: KWS
DATE: 1/95
Q. A. PEER REVIEW: MAF

RUN-ON/RUN-OFF CONTROL PLAN FOR MISTER M LANDFILL
LEWISTOWN, MONTANA
MISCELLANEOUS DETAILS

PROJECT NUMBER
2729.002-010-0112

SHEET NUMBER
5



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NO.	DESCRIPTION	DATE	BY:

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